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UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE

MANUAL OF BARKBEETLE CONTROL IN WESTERN PINE FORESTS

BY

F. P. KEEN

ASSOCIATE ENTOMOLOGIST
U. S. BUREAU OF ENTOMOLOGY

MARCH 1927

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IN

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in
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MANUAL OF BARKBEETLE CONTROL IN WESTERN PINE FORESTS

Introduction

In the last few years the destruction of a large volume of timber through the agency of barkbeetles has forcibly brought home to foresters and timber owners the realization that insects are one of the very serious enemies of pine forests.

As a result, more and more attention is being given to the prevention and control of forest insect losses. Since 1905, when the first control work was conducted against the Black Hills beetle in South Dakota, a large number of projects directed toward the control of western barkbeetles have been carried on. In the last few years the size and number of such projects have notably increased, and each decade witnesses greater expenditures in this work.

On account of the importance of the problem, and in view of the probably greater expenditures in the future, there is distinct need for a summation of past experiences in order that the mistakes that have been made may in the future be avoided and the most efficient methods of today improved.

The purpose of this manual, therefore, is to summarize the present information on barkbeetle control, in order to assist the foresters and timber owners in their fight against these pests. Its field is limited to the problems as they exist in the virgin pine forests of the western United States and to the control of barkbeetles in commercial timber stands. The protection of individual trees around summer homes or in recreational areas is not considered, since this problem is a specialized one, requiring entirely different methods of treatment.

Basis

The information contained in this manual is based upon the experience received in "the school of hard knocks" by the men of the Forest Service, timber protective agencies, and the Bureau of Entomology in the conduct of barkbeetle control projects involving the treatment of over a hundred million board feet of infested timber, at a cost of nearly half a million dollars.

Beside the writer's own experience in directing the work of the Southern Oregon-Northern California Project from 1922 to 1925 and the treatment of nearly fifty million feet of infested timber with an expenditure of $150,000, and the Kaibab Control Project during 1924 and 1925, with an expenditure of over $40,000, he has had access to the reports of other workers in the Bureau of Entomology and the Forest Service, covering a large number of other projects in different parts of the West which have been carried on during the past twenty years.

Published information dealing with this subject is very limited. While there are a great number of books, bulletins, papers and articles that touch upon the forest insect problems of the western United States, very few of these go into the practical details of carrying on control work. The bulletin of Dr. Hopkins on the "Genus Dendroctonus"[1] covers the methods in a general way.

[1] A.O. Hopkins; Bul.83, U.S.Dept.Agr.Bur.Ent.-"Barkbeetles of the Genus Dendroctonus"

Beside this a mimeographed control manual prepared by Mr. Ralph Hopping in 1914 for use in District 5 of the U.S. Forest Service has been very helpful in suggesting points to be covered.

In general it may be said that the methods outlined in the following pages have been developed, not from abstract theory, but as the result of accumulated experience in the practical work of applying artificial control methods.

What Forest Insects Do

Forest insects are one of the destructive agencies that are continually at work in every forest. Some of them act as scavengers to destroy old, weak and useless trees and make room for new ones. But others do much more than this, and kill the healthy and strong and, from man's standpoint, the most valuable part of the timber stand, viz., the mature trees with their large volume of high-quality timber.

Contrary to popular opinion, the destruction of forest trees by insects is not of recent origin. All the species of importance in our western forests are indigenous to this country and have been present in our forests for many ages. Recently a flat-headed borer was found in a redwood tree where it had attacked a fire scar, had been imbedded in the pitch and then covered by twelve hundred years of ring growth. The same species is found attacking redwood today.

Classes of Infestation

The two types of infestation, the passive and the aggressive, have been termed respectively "endemic infestation" and "epidemic infestation".

Endemic Infestation

In the aggregate, the loss of western pine timber through the slow but continuous work of insects during endemic conditions of infestation is greater than that caused by the more spectacular periodical epidemics. The yearly toll from this type of infestation amounts to from .3% to .5% of the stand, as compared with an average annual fire loss of from .1% to .2% of the stand. The total of such loss runs into billions of feet.

However, we find that very frequently the losses from insects, disease and fire are more than covered by the normal forest growth, and do not cause any permanent depletion of the forest capital. As a consequence, the losses from insects, disease and fire in virgin stands become of importance only when they are concentrated on certain areas and destroy more timber than will be replaced by growth during the period preceding the contemplated use of the timber, or in other ways more or less permanently injure the timber stand.

Epidemic Infestations

Like fire, insects frequently concentrate their work on certain areas, and within a few years completely kill out a high percentage of the forest. Such types of work are called "epidemic infestations", and are the ones with which foresters and timber owners are chiefly concerned. The dead trees eventually fall and leave large brush fields or openings in the timber similar to those caused by fire. In some cases such losses are not replaced by normal forest growth within a period of fifty to one hundred years, and in some cases result in a complete change in the forest type.

In the yellow pine forests of California, Oregon and Idaho, during periods of epidemics, as much as five per cent of the stand may be killed over limited areas in a single year by the western pine beetle. The Black Hills beetle in the Black Hills of South Dakota, on small areas through Utah and Colorado and on the Kaibab Forest of Arizona, and the mountain pine beetle in the lodgepole pine stands of the West, have killed from 10% to 90% of all pines over six inches in diameter through large areas of these forests.

The forest insect problem, therefore, resolves itself into devising methods, not of stopping the normal insect loss, but of preventing or controlling the sporadic and highly destructive concentrated epidemic attacks.

What Trees are Affected

Of our western forest trees, the pines undoubtedly suffer the most from insect attack, the spruces and firs to a lesser extent, while the redwoods and cedar-like trees are rarely damaged at all. Artificial control, therefore, is limited to a few species of trees.

Another fact which simplifies the control problem is that the destructive insects breed only in certain trees. For instance, the western pine beetle attacks only the western yellow pine and Coulter pine, while the Jeffrey pine beetle confines its work largely to the Jeffrey pine. The mountain pine beetle is a little less fastidious in its habits, and attacks sugar pine, white, yellow, lodgepole and perhaps other pines, but rarely goes into the spruces or firs. Thus, when control operations are directed toward the reduction of any pine barkbeetle, it is necessary to treat only the pines that are host to that particular barkbeetle, disregarding the other sickly or dying species of trees in the forest.

Therefore, under the economic conditions that prevail today, the control of forest insects in our virgin western forests resolves itself into a problem of controlling epidemics of barkbeetles that are destructive to the commercial pines, and controlling these only on areas where it is expected that the mature timber will be utilized within the next ten or twenty years.

In our second-growth forests or in areas under more or less intensive forest management, an entirely different set of conditions exists, demanding a different conception of insect control. Prevention is the keyword here--prevention through proper adjustment of management to the insects' habits.

Distinguishing the Infested Trees

Trees killed by barkbeetles can usually be distinguished from living trees by a distinct contrast in color of the foliage; but in the early stages of attack they can be told only by sawdust in the crevices of the bark or pitch tubes on the trunk, the presence of woodpecker work, or the discovery of the beetles and their work under the bark of the trees.

When barkbeetles first attack a living tree and bore into the cambium, the tree reacts to the invaders by throwing out a quantity of pitch, which sometimes completely drowns them out. This causes a pitch nodule or "pitch tube" to form at the point of attack, the size of which varies according to the vigor and resistance of the tree. If the attack is successful, the barkbeetles continue to bore their egg tunnels in the inner bark and throw out quantities of yellow or red boring dust, depending upon the color of the inner bark. This boring dust collects in crevices of the bark and around the base of the tree and is often very noticeable. Later, ambrosia beetles attack the moist sapwood at the base of the trees and throw out white boring dust which forms a ring about the base of the tree. This is very characteristic of trees infested by the Black Hills and mountain pine beetles in the higher and cooler forest types.

Trees attacked during the summer often fade to a pale green or straw yellow within two weeks after attack, but trees attacked in the fall usually remain green until the following spring, when with the advent of warm weather they start to fade. The color gradually deepens from straw yellow to yellow, then orange or "sorrel", red, brown, and finally black after the needles have fallen. The infesting insects usually leave the trees about the time they have reached the sorrel stage, so that there is no use in treating trees in the red or black-top stage, since they are usually abandoned. Finally the dead trees lose their bark, and as they are bleached by the weather become white snags or "ghost trees". After about four or five years they fall during a wind storm, decay and return to the soil.

About the time the larvae reach full growth the woodpeckers are attracted to the trees and flake off large patches of bark in their search for the grubs. This woodpecker work is often very characteristic of barkbeetle-infested trees, and helps to distinguish them in cases where the foliage has not changed color.

In making estimates of barkbeetle damage, the sorrel and red-top trees are the most conspicuous, and hence are the ones usually counted by the estimator as a basis for the estimate. Such trees usually include the loss of about two seasons, and a close examination of a series of trees should be made in order to determine what percentage belongs to the loss of the year in question.

The Important Barkboring Enemies of Commercial Western Pines

In respect to their habits, the multitude of insects which may be found on and within a pine tree can be more or less arbitrarily divided into four groups: (1) primary insects, (2) secondary insects, (3) dependents and guests and (4) beneficial insects.

The primary insects are those capable of causing the death of a tree without the assistance of other insects. Secondary insects are those that assist the primary insects in killing trees or independently cause injury to trees which does not result in the trees' death. Dependents and guests are such insects as follow the primary and secondary insects and feed upon decaying vegetable matter or upon fungus or other material, and in no way injure the tree. The beneficial insects are those that prey upon the destructive species and prevent them from becoming too numerous.

Insects that may be secondary in one case may become primary in another instance, and vice versa. Thus the engraver beetles are often secondary to the Dendroctonus beetles in their attack upon mature trees, but occasionally become primary in their attack upon young poles and saplings. In the lodgepole stands of Yosemite the mountain pine beetle at times plays a secondary role in assisting the lodgepole needle miner to kill these trees.

The important primary insect enemies of the commercial western pines are comparatively few in number and, outside of a few defoliators which sporadically cause serious injury, consist of about half a dozen barkbeetles and two flatheaded borers, which burrow between the bark and the wood and kill the trees in a very short period of time. The following lists the more important tree-killing beetles according to their hosts:

The Important Primary Barkboring Enemies of Commercial Western PINES

The Pines	The Beetles
Western White Pine (Pinus monticola Dougl.) Calif.,Nev.,Oreg.,Wash., Id.,Mont.,W.Canada	1. Mountain Pine Beetle (Dendroctonus monticolae Hopk.) 2. Engraver Beetles (Ips spp.)
Sugar Pine (Pinus lambertiana Dougl.) Calif.,Nev.,Oreg.	1. Mountain Pine Beetle (Dendroctonus monticolae Hopk.) 2. Engraver Beetles (Ips spp.) 3. Pine Flatheaded Borer (Melanophila gentilis Lec.)
Western Yellow Pine (Pinus ponderosa Dougl.) Baja California,Calif., Nev.,Oreg.,Wash.,Idaho, Mont.,Wyo.,West.Canada	1. Western Pine Beetle (Dendroctonus brevicomis Lec.) 2. Mountain Pine Beetle (Dendroctonus monticolae Hopk.) 3. Engraver Beetles (Ips spp.) 4. Pine Flatheaded Borer (Melanophila gentilis Lec.)
Rocky Mountain Yellow Pine (Pinus scopulorum (Engelmann) Lemmon) Mex.,Ariz.,N.Mex.,Tex., Utah,Colo.,S.Dak.,Neb., N.Dak.,Wyo.,Mont.,Nev.	1. Black Hills Beetle (Dendroctonus ponderosae Hopk.)
Jeffrey Pine (Pinus jeffreyi (Oreg.Com") Baja California,Calif., Nev.	1. Jeffrey Pine Beetle (Dendroctonus jeffreyi Hopk.) 2. Pine Flatheaded Borers (Melanophila gentilis Lec.) (M. californica V.D.)
Lodgepole Pine (Pinus contorta Loud.var. murrayana Engel.) Baja California,Calif., Nev.,Oreg.,Wash.,Idaho, Mont.,Wyo.,Utah,Colo., S.Dak.,W.Canada	1. Mountain Pine Beetle (Dendroctonus monticolae Hopk.) 2. Engraver Beetles (Ips spp.)

The secondary insect enemies of the western pines are legion, and include many species of insects which are at times quite destructive. In this group we have the secondary barkbeetles, twig borers, gall insects, leaf feeders, and the like. But while these at times may cause considerable damage, no general methods are as yet applicable to their control in virgin forests, and each case must be considered as a problem in itself.

The dependents and guests that are found under the bark of dying trees are often mistaken for destructive species or beneficial ones. If the forester has acquainted himself with the very few primary species he need pay no attention to the insects in this group.

During barkbeetle epidemics the beneficial insects often become very numerous. These should be protected and encouraged through adjusting the control program so as to save as many as possible. Three very common predators are associated with Dendroctonus killings, and are only too well known by treating crews, not for their ability to chew on the barkbeetles but for their propensity to bite the treaters on the neck. These beetles are the red-bellied clerid (Enoclerus sphegeus Fabr.), which is commonly associated with the mountain pine beetle and Black Hills beetle infestations, the black-bellied clerid (Thanasimus nigriventris Lec.), which is the common enemy of the western pine beetle, and a shiny bluish-green Ostomid (Temnochila virescens Fab.), which is a general feeder and is found throughout the western forests on barkbeetle-infested trees.

Recognizing the Important Western Tree-Killing Beetles

The determination of the insect or insects responsible for the injury is a very important point, since the method of control will vary with the different species. A great deal of money can be wasted in fighting the wrong insect or fighting the right insect with the wrong methods. If there is any question as to the insect causing the damage the advice of an expert should be secured, or specimens of the insect and its work should be obtained and sent to an entomologist for determination.

However, most of the commonly injurious species can be readily recognized in the field by the character of their work; and in order to assist the field man in their identification a brief description of the common pine destroyers is given here.

The Western Pine Beetle (Dendroctonus brevicomis Lec.)

These beetles attack western yellow pine and Coulter pine, and range from Southern California north into Oregon, Washington, Idaho, Montana and British Columbia. Trees are attacked singly and in small groups, rarely exceeding fifty trees to a group. Two or more periods of attack occur each season, but fading trees may be found at any time during the year. The character of fading is much the same as for other species. Close examination of the bark will show small circular holes about one-sixteenth of an inch in diameter, and sawdust in crevices of the bark. Between the bark and wood will be found the winding, crisscrossing egg galleries which have been made by the adult beetles. These egg galleries, which are slightly larger in diameter than the beetle, are filled with sawdust, and cross and recross one another in such a manner as to form a network of irregular lines. This peculiar type of egg gallery is characteristic of this species, and can be said to be the hieroglyph or signature of the western pine beetle.

The type of woodpecker work is also very characteristic of infestation by this beetle. The grubs develop in the outer bark, so that the woodpeckers in their search for the grubs flake off irregular patches of outer bark but do not drill holes through to the wood.

Mountain Pine Beetle (Dendroctonus monticolae Hopk.)

This beetle is responsible for the killing of large areas of lodgepole pine, and also causes considerable damage to sugar pine, western white pine and western yellow pine throughout California, Oregon, Washington, Idaho, Montana and British Columbia. This species attacks lodgepole and sugar pines of all sizes, ages and conditions of health and vigor but, at least in California and Oregon, seems to prefer the smaller yellow pines under twenty inches in diameter which are suppressed or lacking in vitality. In this work they are usually associated with the large engraver beetle. Trees infested with this beetle usually fade in the late spring and summer. There is generally one full generation a year, with a partial summer generation. Pitch tubes are often more prominent than in the case of the western pine beetle, and sawdust is usually thrown out in greater abundance. Examination of the inner bark and sapwood of trees infested with these beetles will disclose the nearly straight egg galleries, having a slight turn at the entrance. This type of gallery is characteristic of this beetle, the Jeffrey pine beetle and the Black Hills beetle. Woodpeckers in their search for mountain pine beetle grubs drill holes directly through the bark to the sapwood.

The Black Hills Beetle (Dendroctonus ponderosae Hopk.)

Through the southern Rocky Mountain region and on the Colorado plateau the Black Hills beetle often kills Rocky Mountain yellow pines by the thousands, and in some places all but wipes out the mature forests. It also attacks other pines in this region. Its work is similar in every way to that of the mountain pine beetle, and many entomologists consider them one and the same.

The Jeffrey Pine Beetle (Dendroctonus jeffreyi Hopk.)

This beetle attacks Jeffrey pines in California, and for the most part confines its work to this tree. The type of gallery is very similar to that made by the mountain pine beetle, and consists of one long straight gallery with a slight curve near the entrance and branching larval mines.

The Engraver Beetles (Ips spp.)

The engraver beetles have the habit of attacking groups of small pines and the tops of larger ones. They are responsible for a great deal of "top killing" and the destruction of large patches of reproduction in the vicinity of slashings, in which they readily breed. The trees fade much as they do from attacks of the western pine beetle, but a close examination will not show the pitch tubes of the latter, and much larger quantities of dry sawdust in the crevices of the bark. Between the bark and the wood will be found the egg galleries, which differ from those of the Dendroctonus beetles by being free instead of packed with boring dust, and by having several tunnels issuing from a central entrance chamber. Woodpeckers feed on them only to a limited extent, and make small holes through the thin bark in much the same manner as in their search for the mountain pine beetle grubs.

The Pine Flatheaded Borers (Melanophila spp.)

Many pines on dry exposures are killed by the work of flatheaded borers. The adult beetles lay their eggs in the bark crevices, and the young larvae upon hatching burrow into the cambium or inner bark layers. Trees attacked by these borers fade in much the same manner as from barkbeetle attacks, but pitch tubes and sawdust in the bark crevices are not present, as in the case of the barkbeetles. In chipping under the bark the irregular, winding, flat mines will be found between the bark and the wood and in the bark. These larval mines increase in size with the growth of the grubs and are packed with boring dust.

Recognizing an Increase of Infestation

A few trees dying from insect attack are to be found in any virgin forest. This is the normal or "endemic" insect loss, and can usually be disregarded so long as the loss falls below the annual forest increment. It is only when the factors which control a normal infestation are interrupted that man must enter the fight and by the use of artificial control measures again place the beetles in their normal defensive position.

An increase in barkbeetle losses will be evidenced by an increase in the number of fading and red topped trees appearing through the forest, with usually a tendency of such infestation to occur in groups. This increase will at first be recognized only providing the forest has been under close observation for one or more years.

Such increases in western pine beetle infestation can be expected following periods of unusual drought or heavy windfalls. Epidemics of engraver beetles can be looked for in the vicinity of sporadic logging operations, extensive highway slash, line slash, or windfalls.

Epidemics of the mountain pine beetle in the Yosemite region follow upon heavy defoliation of the lodgepole pine by a needle miner. The causes of outbreaks in other regions are not well understood.

In general, the predicting of barkbeetle epidemics is a very uncertain matter, and usually the best that can be done is to recognize an epidemic after it has started to develop. Forest rangers and others in close contact with the forest will usually be the first to recognize the symptoms of an incipient outbreak.

Prevention of Barkbeetle Epidemics

The prevention of barkbeetle epidemics is more desirable in forest protection than the suppression of epidemics after they have reached an aggravated form. The application of expensive methods of barkbeetle suppression should be undertaken only as a last resort when preventive methods have failed.

In order to prevent barkbeetle outbreaks it will be necessary in the main to rely upon methods of forest management. This will involve first, the keeping of the trees in a healthy, vigorous condition in order that they may be able to resist barkbeetle attacks, and second, the reduction of the destructive beetle population through forest sanitation, which will involve the prompt removal of infested trees, slash, windfalls or other infested material in which injurious beetles breed.

The details of preventive methods are still to be worked out. We do not as yet know how forests can best be kept in a vigorous growing condition, or how they may be kept free from infested material at a cost that will be warranted by the protection afforded. At least under present forest conditions throughout the greater part of the United States, the economy of such intensive preventive measures can well be questioned.

On intensively-used forest areas, such as parks and playgrounds, epidemics are now being successfully avoided at a cost which is entirely justified. On the floor of the valley in Yosemite National Park, infested yellow pines that are killed by barkbeetles are promptly felled and the infesting beetles destroyed. The tree is then cut into stovewood and sold in the camps at a price which more than covers the cost of the control treatment. No barkbeetle epidemics have developed on the floor of the valley since this preventive work was inaugurated.

On recreational areas in Southern California intensive care of the forest is already practised, and barkbeetle control has been put on a permanent basis and is carried on at a cost that is easily justified by the values at stake.

The cost of preventive work should be considered in the same light as timber insurance. The risk or probable loss should be taken into account, and the amount to be spent each year should be looked upon as a "premium" which is paid to insure against this loss. In order to be profitable, the yearly premiums must be kept down to only a comparatively small percentage of the probable loss, as no owner could afford to spend each year an amount equal to or exceeding such probable loss. Suppression work, on the other hand, deals with more tangible values. A certain amount is being lost, and by spending a certain sum so much can be saved; if this will leave a profit, then the work can be undertaken. If, however, the cost of control is more than the timber is worth, then it is best to let Nature take her course.

Detection of Barkbeetle Epidemics

Wherever timber values warrant the expense of protection from barkbeetles, the prompt detection of incipient outbreaks will greatly reduce the ultimate cost of suppression. Such work is analogous to that of the forest fire lookout detection system, and the first reporting devolves upon the men immediately responsible for the protection of the forest, such as the ranger force on the National Forests. To do this work properly requires some knowledge of the barkbeetles that are likely to cause epidemic losses, the ability to recognize infested trees, the ability to recognize an increase in infestation, and some training in the estimating of timber and timber losses.

The Preliminary Reconnaissance

Reporting the first signs of a barkbeetle outbreak will usually devolve upon the men in close contact with the forest. On most of the national forests the rangers are required to make at least one annual reconnaissance of their district and report the conditions as to insect infestations. In this way barkbeetle outbreaks are promptly brought to the attention of the forest officers and a decision as to the proper action can then be taken. Such preliminary examinations should establish whether or not trees are dying from insect attack; what insect is probably responsible for the damage; the character and amount of timber being killed and whether or not a more intensive examination or control operations appear to be called for.

The first step is to determine whether or not trees are dying from insect attack. If scattering healthy pines or clumps of pines are dying and there is no evidence of recent fires, it is usually safe to assume that insects are the responsible agents. A bark examination of the trees in one or more groups is then necessary to verify this assumption. If insects are the primary cause, one or more of the species known to be capable of killing trees will be found. Sometimes trees die primarily from drought or disease and insects later attack them as secondary agents. But in such cases barkbeetles of secondary importance will be much in evidence and the trees will not consistently show the work of primary tree-killing species. If the cause of death cannot be satisfactorily determined, an expert should be called in or samples of the work and the insects present sent to an entomologist for his determination. Samples taken from the middle stem are more apt to include the primary destructive beetles than if taken near the ground, where secondary insects are usually most abundant.

Estimating the Barkbeetle Damage

Having determined the insects responsible for the dying trees and the means by which the infested trees can be recognized, the next step is to make an estimate of the total seasonal or current yearly loss on the forest or area in question. Such estimates are usually made either by counting from ridges or lookout peaks the discolored trees visible on an area of known size, or by running sample strips through the forest and counting the dying trees on a known area on either side of the strip.

The methods described under "Detailed Surveys" are applicable to this purpose. In any case a small sample plot or strip should be cruised in which the total number of infested trees are examined and counted. This can then be used as a basis for estimating the proportion of yearly loss represented by the discolored trees, and helps in judging the relative amount of infestation on the rest of the area.

Reporting Barkbeetle Conditions

Only a few of the pertinent facts are needed in the first report of an insect epidemic, and these should be brief and tersely stated; they should include information as to where the infestation is located, extent of the damage, the insect probably responsible and whether or not further action should be taken. In the appendix is given an outline that suggests the points to be covered in reporting a preliminary reconnaissance of an infested forested area, and a report form whichbhas been used in the California District of the U.S. Forest Service for the annual reports from rangers is also appended. In this annual report, where no unusual conditions exist, only the first six questions are filled out, but where an infestation of importance seems to be developing the additional data are given.

The Estimation Survey

After an infestation has been reported by the men on the ground, and before control operations are started, there is usually need for a more complete field examination or survey in order to secure the necessary data upon which to base the control program.

Such surveys are generally carried out with the object of determining the extent of the infested area, the species of insects responsible for the damage, the probable progress of the infestation, and the probable number of trees or volume of infested timber which will have to be treated if control operations are undertaken. The work is usually done by forest insect control experts who have had experience in estimating barkbeetle losses and planning control campaigns.

Where large areas comprising a number of different forest types and topography are involved, several different estimating methods or combinations of methods are used. Sample plots are intensively cruised and later viewed from a distance to determine the ratio of visible to actual infestation. Sample strips are run through the more heavily forested areas of flat topography and counts are taken along roads and trails, while the portions with steep topography are estimated by the topographic viewing method. Every available source of information should be utilized in arriving at the final estimates, and the more survey data at hand the more accurate will be the final result.

1. Topographic Viewing

This method is particularly adapted to estimating barkbeetle losses over large forested areas of rough topography, where a large part of the forest can be viewed from open valleys, ridges or lookout points. It is subject to a high degree of error unless supplemented by intensive examinations of sample plots, in which case the estimate can be considered as fairly reliable.

In using this method the estimator, equipped with binoculars and a topographic map of the area, "gridirons" the country by traveling along the ridges or open valleys or wherever an unobstructed view may be had of most of the timbered area. At selected points along the route, the opposite slopes or areas visible and not more than two miles away are viewed either with the naked eye or with the binoculars, and the red, sorrel or faded trees counted. These are then spotted on the map within the area which has been viewed, either by dots or by numbers, to indicate the number of trees that have been counted. All the country that can be viewed is covered in this manner.

To determine what percentage of the trees have probably thus been counted, a check plot which has previously been viewed should be intensively cruised and the ratio between actually infested trees and the number viewed on this area determined. Experience has shown that in general through the western yellow pine type, the number of discolored trees counted by the viewing method on slopes not more than two miles away will have to be multiplied by two to arrive at the approximate number of infested, dying or dead trees on the ground.

The field notes from a survey of this character should consist of a spotted map, preferably on a half inch to the mile scale or larger, showing the actual number of trees viewed (before the correction factor has been applied) and their location; and a notebook in which notes have been taken on any important observations, such as the general character, extent and aggressiveness of the infestation, location of the heaviest centers, the insects causing the damage, the timber type and sites involved, and any contributory causes responsible for the present situation.

2. Sample Strip Counting

Topographic viewing in forests of gently rolling topography is often impossible. For this type of country a sample strip method of survey is most suitable. It is also somewhat more accurate than the topographic method, and even inexperienced observers can count the number of infested trees in a strip and secure a fairly reliable estimate of the loss. However, in order to cover any large area a great many strips must be run, which makes the method more laborious and consequently more expensive.

In using this method the observer travels through the forest along some route of known position and length, either a forest road, trail, section line or by using a compass and paces, along a paced line in any known direction. Without attempting to blaze or mark the trees, the number of fading, sorrel, or red-topped trees are counted within a two-, four- or five-chain strip on either side of the line of travel. The width of the strip will depend on the density of the stand, and should be so chosen that its outer edge corresponds to the average limit of vision on either side of the line. For the open western yellow pine stands in California and Oregon a ten-chain strip (five chains on either side of the line) has been found most satisfactory. In stands mixed with fir an eight-chain strip is generally used, and for very dense stands of fir or lodgepole pine a four- or even a two-chain strip will be found to correspond to the limits of vision. By examining a representative series of trees, either on a sample strip or on a sample plot, the proportion of different classes of insect attack and years of infestation may be determined to apply to the total figures as secured from the sample strip counts. The average diameters, heights and volumes to apply to these different tree classes may also be determined from the sample strip or plot. The number of trees counted in each mile of strip, multiplied by the ratio of the strip acreage to the acreage of a square mile will give the approximate number of trees per section for the locality in which the strip is located.

The field data should be entered on a map, preferably one inch to the mile or a larger scale, and should show the timber type, roads, trails, ridges, route taken by the estimator, and number of trees killed for each mile of strip. In the field notebook should be entered similar data to those listed under the previous method.

Sample Plot Marking

In order to secure more detailed information on the classification of the discolored trees according to seasons and beetle generations, and to determine the ratio between the actual number of trees on the ground and those counted by the topographic viewing method, it is often desirable to cruise intensively a sample plot representative of the typical forest conditions on the area. In this case all the trees showing a particular type of insect injury or representing the loss of the past year or two are marked, listed and mapped. The boundaries of the plot are also established so that it can be cruised again in other seasons, and the change in the status of the infestation accurately determined. Such a plot may be anywhere from 1 to 640 acres or more in size, but usually either a half or a full section is selected as being large enough to give a fair sample of conditions in the vicinity. The plot may be cruised by either of two methods, (1) the strip method pr (2) the topographic method.

1. Strip Cruise

The strip cruise is particularly adapted to the surveying of any limited forest area where the topography is not too steep to hamper the running of strips in straight lines. It consists in laying and establishing the boundaries of a definite area and then locating, marking and measuring all insect-killed trees that have died within a given period.

On areas which have been previously surveyed and sectionized, the best plan is first to rerun these land lines and use them as a base for the survey, or if the lines are sufficiently well marked they may be used without rerunning. Where no land lines are available, a base line should be established through the middle of the plot, the line trees blazed, and markers set at regular intervals. These are later used as starting points for strips which are run at right angles to the base line.

With the aid of a surveyor's compass, strips are run back and forth across the area often enough so that every tree of the class to be marked is brought within the close view of the examiner. The width of the strip depends on the density of the forest stand and the amount of infestation, but as a rule it varies from two to five chains for each examiner or "spotter". In fairly open stands a five-chain strip can be satisfactorily handled by each spotter. If the stand is dense or the infestation particularly heavy or hard to locate (as in fall spotting) the width of the strip should be cut to four or even to two chains.

The trees are blazed, numbered and mapped, the essential data being recorded on prepared forms (see sample form in appendix). The work is best carried on by a crew of three men, consisting of one compassman who runs the lines, maps the trees, notes the topography and timber types, and records other general data pertaining to the area as a whole, and two spotters who work a strip on either side of the compassman, mark and number the trees and record such data as pertain to the individual trees.

The field notes should consist of a map on a two inch to the mile scale or larger, on which the infested trees are located and marked with their serial numbers, corresponding to the numbers placed on the trees by the spotters; a tree list on which is recorded the serial number of each tree, its breast-high diameter, height, primary infesting insect and such other notes as may be desired. For special studies, where considerable extra data are to be recorded for each tree, the tree lists may be replaced by individual tree records. A field notebook may also be kept in which is recorded any special information concerning the character of the infestation, the timber types, site classification, exposure and other general field notes.

This method is necessarily slow and expensive. With infestations ranging from 40 to 250 trees per section, a crew of 3 men can cover about 320 acres a day at a cost averaging about $35 per section, or from 4 to 6 cents per acre. For infestations in excess of 250 trees per section, the acreage which can be covered per day will be reduced and the cost per acre increased. A 3-man crew can spot and tag a maximum of only about 500 trees per day when the infestation is very heavy.

2. Topographic Cruising

A topographic cruise is best suited to a rough, mountainous country with well defined drainages and steep slopes.

The method is simply a modification of the strip method in which the strips are curved lines instead of straight, and are made to fit the topography of the country by following the general direction of the contours.

As in the previous method, the boundary of the area should first be established, either by rerunning the land lines or by marking the boundary along prominent ridges or streams. A good topographic map is very desirable for such work, and if one is available the boundaries may be indicated on the map without marking them in the field. Starting at one corner of the area the spotter works back and forth, parallelling the contours and marking all the trees within a two- to five-chain strip above and below his line. No compass is used, and the work is best carried out by one man working alone. Each small drainage is worked out in this manner until the entire area has been covered.

Since no compass is used and distances are not paced, there is a tendency of the traverse lines to overlap and for part of the area to be more thoroughly covered than other portions. For this reason the method is not so accurate as the strip method and should be used only on areas not suited to strip spotting.

The same field notes are taken as in the strip cruise method, except that the map will have to be prepared in advance of the field work and used by the spotter in locating his position on the ground.

With infestations ranging from 40 to 250 trees per section, one man can cover from 80 to 320 acres per day at a cost varying from $10 to $50 per section, or from 1½ to 8 cents per acre. With infestations over 250 trees per section the cost per acre will increase but the cost per tree will decrease.

Circular Acre

Occasionally data are desired as to growth conditions, the percentage of increment killed, or other information of a detailed nature for a small sample plot in a given forest type. For these purposes a sample circular acre is often most convenient.

To lay off such a circular acre, first select the desired center, either the middle of an infested group of trees or a point surrounded by typical forest conditions. Then pace or measure from this center a radius of 118 feet in four or more directions and mark the outer circumference of the plot. By working back and forth within this circle all the trees within it can be counted and studied.

Size of Crew for Survey Work

The number of men to be employed in making a barkbeetle survey will depend upon the available personnel familiar with survey methods, the area to be covered, the accuracy desired and the time and money available.

The extensive work of topographic viewing and sample strip counting can be handled by one man working alone, provided he is familiar with the country. If not, it is often advantageous for him to have as guide some ranger or other man who is familiar with local conditions. By these methods one man can estimate from 2000 to 6000 acres per day, depending upon the character of the country.

For the sample plot marking by the strip-cruising method, a three-man crew is most desirable. One man then acts as compassman, carries the line and does the mapping, while the other two men do the spotting and work within a strip on either side of the compass line. A two- or four-man crew is not so efficient for this work as a three-man crew.

If, as is usually the case, the survey is to include both the extensive work of topographic viewing and strip counting and the intensive work of sample-plot marking, there is a distinct advantage in having a three-man field party. For the extensive work, each man works independently and covers a large expanse of country, and then for the intensive work the three-man crew is available.

Accuracy of the Survey Data

In the extensive surveys various factors interfere with the accuracy of the data. Thus, poor light and unfavorable topography may interfere with the counting of trees. The sample plots may not be representative of the infestation in the area around them, and the number of trees actually studied on the sample plots or strips may be insufficient for the accurate determination of average volumes and the proper ratio of the insect loss according to seasons. Then there is always the personal equation. An estimator may fail to do careful and thorough work, or he may possess an inherent tendency to over- or underestimate. However, it has been found that, regardless of these factors, the estimates will ordinarily vary not more than 25% from the estimates obtained by a complete cruise of the area.

The accuracy of intensive surveys will depend upon the width of the strip covered by each spotter, the time of year the survey is made, and the personal equation of the spotters themselves.

The width of strip should be adjusted so that all the infested trees are brought under the observation of the spotter. It should not be greater than five chains unless all the trees are very conspicuous by their color and the timber is of an open type that can be readily viewed. If the timber is dense or if many of the trees have not faded, the width of strip should be less than 5 chains, or many of the trees will be missed. We have no exact figures as to the influence of the width of strip on the accuracy of the work; but recruises of certain sections in southern Oregon have shown that where a four-man crew attempted to spot a strip 20 chains wide in spring spotting, 40% of the trees were missed.

The time of year in which the survey is made, as related to the fading of the trees, is a very important factor in determining the accuracy of the survey. This has been pretty carefully worked out for the western pine beetle in southern Oregon. In this region, if the survey is made in September of the year of attack only about 27% of the total annual loss will ordinarily be spotted. If the survey is made in December 50% will be spotted; in April of the following year 75%; in July and August (after all trees have faded) 93%. If, however, the survey is made any later than July or August following the year of attack, less than 93% of the infestation will be located, due to many of the trees turning black and becoming inconspicuous or indistinguishable from trees of older generations. Thus in July or August of the second year after attack, only about 60% of the loss will be spotted.

In control spotting it has been found that approximately 76% of the overwintering generation of the western pine beetle may be spotted in the fall, from the first of October to the first of December (southern Oregon); that 80% will be spotted in the winter from December first to March first, and that 85% will ordinarily be spotted in the spring work between March first and June first.

For the Black Hills beetle infestation on the Kaibab it has been found that during the fall, from September 1 to October 15, 65% of the infestation will be located in one spotting of any area, using a 3-man crew and a 5-chain strip per spotter. In the spring, from April 1 to July 1, as high as 96% of the trees will ordinarily be found.

The most serious errors will be due to the personal equation of the spotters. Some men simply are not built to be good observers and may easily miss half the trees that another spotter would find. This factor should be determined and taken into consideration in using the results from any survey.

Compilation of the Field Notes

When preparing estimates of timber losses, the first step in compiling the field data is the preparation of a map on which is entered all the counts from sample strips, intensive plots and topographic reconnaissance viewing. This map should preferably be on an inch to the mile scale or larger. The map should also show the boundaries of the area, the boundaries of the openings, changes of type and the approximate stand of timber on various portions of the area, or the timber site classes.

With all that is pertinent to the subject thus assembled and at hand, an estimate of the current losses can readily be made. Each section or other small subdivision should be studied separately. The timber type, character of stand, area timbered, strip counts and number of trees counted from a distance should all be considered before arriving at a final estimate. The estimate is usually best made in terms of the number of trees killed during one year. With sample measurements from the intensive plots the average volume of the trees can be determined and such figures applied to the total to determine the volume of the loss. After an estimate has been made for each section or other unit, the totals for the area are secured by simply adding up the estimates on the individual sections.

Preparation of Reports

As a guide for the preparation of reports two outlines are appended which suggest the subjects to be covered and the order in which they should be taken up. Every survey will present new problems that must be handled in a different way, but in nearly every case the general arrangement of the report could be well submitted in the form suggested by these outlines. The use of the outlines will not only help the man who has to prepare the report in preventing him from forgetting some important item, but will help the reader who has to summarize or analyze a number of such surveys made either on different areas or on one area by different individuals.

A sample map is also appended, giving a standard set of colors which can be used in designating infested areas.

Suppression of Barkbeetle Epidemics

The suppression of barkbeetle epidemics may be undertaken by either indirect or direct methods of control. Indirect methods of control may be by the regulation of either ecological or biological factors, while the direct methods of control include such methods as actually destroy the beetles or remove them from the forest.

Indirect methods of control through the regulation of some environmental factors may in time prove to be the most satisfactory way of handling barkbeetle epidemics. As yet, however, our knowledge of this phase of the problem is very limited, and no definite recommendation can be made.

Direct suppression measures are therefore the only available weapons that we now have at hand; and frequently such a program of suppression is warranted over large areas of virgin forest, where an intensive preventive campaign is not feasible.

What Are the Chances of Success?

Direct suppression methods depend for their success upon effective ways of actually destroying the infesting beetles or removing them from the woods. Any method that is successful in accomplishing such destruction or removal may be considered as an effective method. However, the most serious difficulty encountered is not in ways of destroying the beetles but in finding a high percentage of them, and here is where the well-trained spotter is of great importance.

Such projects as have been carried on in the past have shown that where a high percentage of the infesting beetles are removed from the woods or destroyed in the bark, the effect has been to reduce the infestation for at least the following year.

The positive results of past projects have been to show that:

(1) The present methods of control, when directed against epidemic infestations, have a pronounced effect (which is evident over and above the effect of natural control factors) in either reducing the losses from depredations of the beetles or preventing increases in their number.

(2) This effect of control also depends upon the amount and thoroughness of the work.

(3) The only way to secure adequate protection is to put the control work on a permanent basis and do the work whenever it is necessary.

(4) The cost of applying control as compared with the value of the timber that can be saved thereby will determine to what extent control work can be profitably undertaken on any area.

The work on the past projects has also shown that control work cannot be expected to accomplish the following results:

(1) It will not exterminate the beetles in our western pine forests, since they are too widely spread and too well established to be so easily eliminated.

(2) Killing beetles on one owner's timber land will not kill the beetles on his neighbor's infested tract, but may lessen them to some extent by their flying over into the cleaned area.

(3) Killing beetles one year will not in itself cause the next year's crop of beetles to die, but owing to their lessened numbers it may, unless conditions are exceptionally favorable to them, take several seasons for the beetles to reestablish themselves.

(4) Control will not upset the natural outside influences which bring about favorable or unfavorable conditions for beetle increase.

(5) One treatment of an area will not result in permanent subjugation of the beetles.

When Are Direct Suppression Methods Warranted?

Suppression campaigns, because of the extensive areas involved, are unavoidably expensive, and can be profitably carried out only on areas of high commercial value. In general it may be said that the cost of suppression (not prevention) should not exceed the value of the timber saved by such work. If, for instance, one tree can be saved for each tree treated, the cost of treatment per tree should not exceed the value per tree; or if only one tree can be saved for every two trees treated, then the cost of treatment per tree should not exceed half the value per tree, and so on. In other words, the current value of the timber, from either a commercial or esthetic standpoint, should be an important consideration in determining the advisability of any suppression program.

Satisfactory cooperation of all affected owners should be another prerequisite in determining the advisability of the suppression campaign. Control cannot be successfully carried out on any small area unless it is completely isolated from all other infested tracts. California and Oregon now have state laws which provide the State Forester with police powers to carry out eradication work on all lands within a zone of infestation, provided owners of sixty per cent of the timber land petition to have such work done. These laws provide a very effective means of bringing into line a few recalcitrant owners who might otherwise jeopardize the success of control work by refusing to clean up their timbered areas.

To sum up, then, it may be said that direct control methods are warranted when:

(1) An increase in beetle losses is imminent, or when an infestation has already become or is becoming epidemic;

(2) The threatened timber is worth more than the estimated cost of control;

(3) It is impractical to reduce the losses through indirect methods or through means of utilization;

(4) Control can be applied over a large enough area to give effective results.

And direct control methods are not warranted when:

(1) The beetle losses are naturally declining or are endemic;

(2) The infested timber is not worth the cost of applying control measures;

(3) The infestation can be removed through selective logging or utilized at a profit;

(4) The cooperation of all owners of an infested tract cannot be secured, thus rendering effective work impossible.

Suppression Methods

Having decided upon the inauguration of a suppression campaign, the next step is to determine the best method to be used. This will depend upon the barkbeetles doing the damage, the tree species involved, the size of the timber, the accessibility of the area, and the possibility of salvaging the treated timber.

The possibilities of utilization should first be considered. If the infested trees can be logged and removed from the forest, or placed in lakes or millponds and the lumber utilized, there is the possibility that the value of the lumber saved, when deducted from the total cost of the operation, will result in a lower net cost than carrying on control by any other method. There is even the possibility of doing the work at a profit. If, however, the infested timber is widely scattered over inaccessible areas, logging is usually out of the question, and burning, peeling or similar methods will have to be used.

Even where the burning or peeling methods have to be used in order to control the beetles, occasionally the treated timber can be salvaged. Following the control work in the Clover Creek unit of the Southern Oregon-Northern California Project in 1923, the scorched logs were sold for $1.00 per thousand board feet to a logging operator who removed them from the woods and hauled them to a mill some eight or more miles away. On the Kaibab Project in 1924, many of the peeled logs were utilized for the local construction of rustic cabins and hotels, being cut into lumber by a small mill constructed for the purpose.

Control Through Logging

Among the methods proposed by Dr. Hopkins in 1909 for the control of Dendroctonus barkbeetles were "(a) by converting the logs into lumber and burning the slabs; (b) by placing the logs in water, and (c) by transporting the infested trunks a sufficient distance (20 to 50 miles or more away) from the forest and away from any living spruce or pine, so that the beetles emerging from them will find no trees to attack." So far these methods have been used to only a very limited extent, and their possibilities and comparative costs have not been fully determined.

(a) Control through logging and burning slabs. One of the first methods to be used in the control of the Black Hills beetle in Colorado consisted of cutting the infested trees, converting them into lumber and burning the slabs. This work was carried out in the winter of 1907 and spring of 1908 under the direction of Mr. W.D. Edmonston on an estate near Idaho Springs, Colorado. Two hundred and forty thousand board feet of infested timber was cut and taken to the mill. This work was very successful in cleaning up the infestation, and was carried out not only at no expense to the owner, but at a net profit of approximately $5.00 per thousand on the 240,000 board feet cut.

Since that time no further work involving the use of this method has come to our attention, although undoubtedly many areas in the vicinity of logging operations have unwittingly been freed from beetle infestation through the removal of infestation in the cut logs and burning the slabs at the mill. It is a method well worth considering when control of barkbeetles becomes necessary and where it is practicable to send the infested material to a mill.

(b) Control through logging and submerging the logs. The Arrowhead Lake Company in the summer of 1922, under the direction of Mr. J.M. Miller and Mr. R.D. Hartman, placed a quantity of Ips-infested poles, which had been cut in the construction of roads, in the lake, to prevent these beetles from escaping and attacking green timber. The poles were later removed and cut into stovewood. The surprising thing encountered in this work was the fact that the beetles were not killed by a submergence of several days or even several weeks.

Following this experience Mr. Wagner, under the direction of Mr. Miller, carried on some experiments at Northfork, Cal., with the submerging of yellow pine bark infested with the western pine beetle. Sections of bark were submerged in a spring, in water of a constant temperature of 70 degrees F., and a section was removed and examined each week. Two and three weeks' submergence failed to kill any high percentage of the broods, and five weeks' submergence was required to bring about 100 per cent mortality. As yet no tests have been carried out to determine the efficiency of the method in killing barkbeetles in logs placed in mill ponds. It is quite possible that many logs would always float with one side exposed to the air, and that some of the beetles would escape from this portion of the log; it might also require more than five weeks to kill those broods which were submerged.

(c) Control through logging and removing infested material a sufficient distance. An Idaho lumber company in 1922 found that on one of their yellow pine tracts of about 3000 acres, from 15 to 17 per cent of the timber had been killed by beetles. In order to control this infestation the company moved their working plans ahead ten years and started cutting the timber in August, 1922. Both green and recently-killed trees were felled and removed to the mill, which was some thirty miles distant. The green logs were left in the woods long enough to absorb emerging beetle broods, and in this way the bulk of the infestation was removed from the woods. The project closed in the fall of 1923, and in August, 1924, an examination of the timber surrounding the cutting failed to show any infested trees within a half mile of the area.

The Bark-Burning Method

Consists of: The bark-burning method consists in felling the infested trees singly or in piles, and scorching or charring the bark sufficiently to kill the infesting broods. For groups of trees up to 20 inches in diameter the quickest and cheapest method is to fall, skid or buck the logs into piles and cover the butt logs with sufficient debris to insure a good burn. For trees over 20 inches in diameter it is usually necessary, unless the trees occur in large groups, to treat them singly, in which case the bark from the top half of the log should be peeled throughout the infested length, and this bark piled alongside the log and then burned. Even if these trees are treated in piles, the tops and sides of the outermost logs should be peeled to insure an effective killing.

Applicable to: This method is applicable to the treating of any barkbeetle infestation, and is the method most widely used in barkbeetle control work on account of its cheapness, its effectiveness in disposing of the beetles and in cleaning up the slash that results from the operation. It has been used not only for the control of beetles that work in the bark but those that work between the bark and the wood. It has of course certain disadvantages, the most serious of which is the fact that the burning of the bark and slash in the late spring creates an attractive influence which is apt to bring in beetles from the surrounding country and concentrate them in the vicinity of the control operations. This has been most noticeable in the case of mountain pine beetle infestations in lodgepole pine. In Yosemite Park, the concentration of beetles on the control area following spring burning more than offset the benefit from the work. The fire hazard, especially in late spring work, is another serious disadvantage, and control operations often have to be halted in early spring on account of this menace.

Details of the Method

Felling Wherever possible the trees should be felled in an open place, where their treatment will cause the least possible damage to reproduction and green timber. In order to simplify the work of the limbers the trees in a group should be felled with the trunks parallel; this also simplifies the rolling of the logs into piles. If possible, stumps should be cut close enough to the ground so as to include all of the infestation. On sloping ground the trees should be felled downhill or uphill and never on the contour, as otherwise the fire will be hard to control. "Bedding" heavy logs--i.e., keeping them off the ground by laying down poles or logs on which they may rest--is sometimes desirable where burning conditions are unfavorable and it is necessary to place pitch and dry material along the under side of the logs to create a draft and insure complete burning of the bark.

Limbing. After each tree is felled it should be limbed, and the limbs cut off very close to the trunk. This is not only easier to do than to leave a stub, but it saves barked knuckles when the trees have to be peeled and simplifies the rolling when the trees are burned in piles.

Piling. Where trees occur in groups they should be thrown together and burned in piles. The size of the pile will be determined by the number of infested trees closely adjacent and the amount of space available in which to burn them. Where the space is limited the piles should be kept close to the ground in order to reduce the size of the fire. In order to secure a good burn, the logs should be piled parallel and close together, with plenty of inflammable material on the ground. After the piles are formed the limbs are usually thrown back over the logs, and the tops cut off and brought back over the piles in order to dispose of the slashings.

In lodgepole pine control operations, horses have been used to skid the logs out into an opening and deck them where they can be burned without injuring green timber. This has resulted in a saving of man labor in the handling of the logs, and has permitted the burning of the trees in large piles, but has materially increased the cost of the operation. Records show that 50 per cent of the cost of treatment by this method is due to the moving of the logs and the brush piling.

Peeling. When peeling of trees over 20 inches in diameter is necessary, all infested bark on the top half of the log to well down on the sides should be removed and stacked along the log. The peeling should continue far enough into the tops so that the burning of the tops, brush and limbs will destroy the beetles in the remainder of the trunk. Usually this means peeling the logs to below a 20-inch diameter limit. Infested bark on the stumps should be peeled and piled on the log to burn.

Brush Disposal. In order to conform to good forest practice and reduce the fire hazard, the brush and slash from control work should either be burned or spread out where it will decay as soon as possible. In wet weather the limbs and brush should be piled over the logs and burned with the bark. In late spring or early fall, when the forest is dry, the brush should be scattered outside the fire lines and kept out of the fire. Disposing of brush by burning in separate piles adds 25 per cent to the cost of the work.

Burning. The fire should be large enough to burn completely all the infested bark, and yet not so large as to make it difficult to control or to cause damage to adjacent standing timber. This can largely be regulated by the amount of material left within the fire lines.

Under wet conditions, the placing of pitch or other dry material along the trunk often becomes necessary in order to secure a satisfactory burn.

As the ground cover dries out a fire line becomes necessary, and should be constructed just as soon as there is any tendency for a fire to remain active over night. It should be constructed as close to the tree as is compatible with safety in burning. The line itself should be a cleared path at least two feet wide, raked or shoveled down to the mineral soil, and should completely encircle the tree but exclude the stump. This precaution is advisable since many predaceous insects pupate in the soil at the base of trees containing advanced broods of the beetles, and by preventing the burning of the debris around the stumps these insects are saved. To prevent basal injury to standing live trees within the fire line, all needles and debris at the base of such trees should be removed.

Under very dry conditions, fires should be started on the uphill or leeward side of the trees on the edge of the fire line, and the trees burned by "back-firing" down the hill or against the wind. Under these conditions it is often best to burn the trees only early in the morning or in the late evening, when the wind and humidity do not add materially to the fire risk.

By regulating the amount of material to be burned and the width of the fire line, burning can be done at any season of the year and on the most hazardous areas without injury to the rest of the forest. However, summer burning is not advisable, both because of the extreme danger and excessive expense involved in handling the fires, and the poor results secured from summer work in controlling the beetles. When burning of the tops and limbs will cause injury to standing trees, it is best to run the fire line under the log so as to exclude this part of the tree, and construct the line close to the tree so that only the infested bark will be burned. In this case the fire should be started at the point where the line crosses under the log, so that it may be made certain that the fire does not jump into the top before the tree is left unguarded.

Allowing fires to escape is usually an indication of careless or poorly-planned work. It takes, however, considerable experience and skill to burn during dry weather without danger to the forest, and new crews must be given a great deal of supervision. Therefore the plan of having special crews do the burning where the situation is at all hazardous and the bulk of the labor inexperienced in control work is a good one.

Size of Treating Crew

In yellow pine control operations, the usual size of the treating crew is either a two- or a three-man crew. A two-man crew is best suited to treating work where fire lines do not have to be constructed. Where this size of crew can be used it is preferable to the three-man crew. It is not difficult to divide the men into congenial pairs, "partners" or men of equal ability. This makes for efficiency; it also makes it easier to tell if any man is loafing on the job, as the results will quickly be evident. A three-man crew is best adapted to the treating work when fire lines have to be constructed. Two of the men fell, peel and prepare the trees for burning, while the third man constructs the fire line and takes care of the burning. The third man is needed in this case to assist in carrying the extra fire tools.

When the infestation is heavy and the crews can be worked closely together, a system of dividing the work into specialized jobs has at times been used. Under this system expert timber fallers do the felling of the trees, buckers and limbers do their part, a peeling crew removes the bark or a team skids the logs into a pile, and then a fire crew comes in to handle the burning. This system has been most frequently used in lodgepole pine projects in which crews of four, six and eight men have been used. These consist of:

2 fallers,
1 swamper,
1 bucker,
2-4 log and brush pilers and burners,
1 skidder and horse,

in which case one man is made the crew foreman at a slight increase in pay. Some degree of efficiency can be secured by this system but, because of the increased walking time involved, it cannot be used if the trees are scattered and difficult to find. In general the use of larger crews is not advisable, and greater efficiency can be secured by working the men in small units.

Effectiveness of the Method

When properly done there is very little question of the effectiveness of the burning method in killing the beetles in the trees treated. Examination of many logs treated in the ordinary course of such work on several projects has shown that fully 99 per cent of the beetles are destroyed. The weak point in control work is not so much in the method of killing the beetles as in finding all the trees carrying infestation. The spotting then is of paramount importance.

Rate of Treating

The amount of work per day which can be accomplished by the treating crews will vary for the different types of projects, and will largely determine the cost per tree or other unit of treating work. The average rate of treating for some of the typical project conditions is as follows:

In the western yellow pine type of Oregon and California, with infestations of the western pine beetle running from 60 to 120 trees per section and averaging 1000 board feet per tree, the number of trees that can be treated by a three-man crew using the burning method, where fire lines are made, will vary from 4 to 10 trees per day, with an average of 2.22 trees per treater per day. When fire lines do not have to be made, the rate of treating will increase to about 2.6 trees per man per day. In summer burning, when extra precautions have to be taken and the bark burned in piles or in pits, the rate of treating will be reduced to about 1.2 trees per man per day.

In the yellow pine forests of the southern Rocky Mountain region infested with the Black Hills beetle, where the killing occurs in large groups of small-sized trees, the burning can be carried on by decking the logs into piles and burning them without the necessity of peeling. Here, with infestations running between 165 and 215 trees per section, and with trees of an average volume of about 250 board feet per tree, a three-man crew can treat from 13 to 15 trees per crew per day, or an average of about 4.75 trees per treater per day. Table 6 gives a summary of the comparative treating rates for these various types of projects.

The Peeling Method

Applicable to: The peeling method is most applicable to the control of those barkbeetles which in the immature stages work between the bark and the wood and die of exposure when the bark is removed, and for the treatment of trees which are easily peeled. It has been very extensively used in the control of the Black Hills beetle in Colorado, Utah and Arizona, and in the control of the mountain pine beetle in sugar and white pine in California, Oregon, Idaho and Montana. It has the important advantage of involving no risk from fire and can therefore be used during dry seasons. On the Kaibab work in 1925 the peeling method was found to be cheaper than the burning method for the treatment of single isolated trees below 30 inches in diameter.

It has the disadvantages of being usually slow and tedious work and therefore more costly than the burning method, and leaves in the forest a mass of slash and debris which seriously increases the fire hazard and which can be disposed of only at considerable extra expense.

Consists of: The method consists of felling the trees across other logs to hold them off the ground, and removing all the infested bark with an ax or barking spud. In the treatment of trees where all the infested bark is within 20 feet of the ground the barking has been done with long-handled barking spuds without felling the trees. Such work has been done more cheaply than where the felling of the trees becomes necessary.

Peeling--Details of the Method

Felling. The felling of trees that are to be peeled differs materially from the felling of trees to be burned. For burning the trees should be felled parallel to one another and then rolled into compact piles, but for peeling it is necessary to "jack-straw" the trees or fell them across one another so that the under side of the logs can be easily reached by the peelers. This results in a jungle of crisscrossed logs which from the fire-hazard standpoint is a distinct menace to the forest. Small logs can be felled, trimmed and then rolled to reach the under bark surface, but the rolling of logs over 20 inches in diameter is often impracticable. Trees infested only basally can be peeled without felling by using long-handled spuds, provided the bark slips easily.

Limbing. All trees felled should be limbed and the limbs cut off close to the trunk so as to avoid stubs.

Peeling. Peeling is most easily accomplished by the use of an ax, although special barking-spuds have been used on some projects. The peeling should be carried as far into the top as infestation is to be found, and all infested bark removed.

Brush Disposal. Brush should be disposed of in the same manner as in the burning method--either spread on the ground or placed in compact piles to be burned in the fall. Where brush piling is required an additional allowance of 25 per cent to the total cost should be made.

Size of Treating Crew. The peeling method can be most efficiently handled by a two-man crew. Two men are needed to fell the trees, and two men can work at peeling a tree without getting in each other's way.

Effectiveness. Peeling is a very effective method of killing those beetles that live in the immature stages between the bark and the wood and are exposed when the bark is removed. On thick-barked sugar pines and occasionally on yellow pines the mountain pine beetles form their pupal cells in the inner bark and are entirely protected by layers of bast. Peeling in such cases does not expose the immature stages to the air, and hence some of the brood complete their development. Often the bark adheres very tightly to the trees and cannot be entirely removed, in which case some beetles escape the treatment. However, records taken on the Kaibab project in 1925 showed that in the ordinary course of the peeling work 97 per cent of the broods were destroyed. This is a sufficiently high percentage to rate the method as very effective.

Rate of Treating. Just as with the burning method, the rate of peeling will vary with a great many factors, most important of which are the size of the trees, amount of bark surface to be removed, method of slash disposal, efficiency of the crews and the cost of labor.

In the control of the Black Hills beetle in the yellow pine forests of the southern Rocky Mountain region, with trees averaging 22 to 24 inches in diameter and 40 to 45 feet in height infested, and where the method consisted of felling, limbing, peeling the infested length and piling the brush, from 3.7 to 3.9 trees per treater were treated per day. With trees averaging 18 inches in diameter and the brush left where it fell, 6.1 trees per day were treated for each man in the treating crews.

In the northern Rocky Mountain region, yellow pine infested with the Black Hills beetle and lodgepole pine infested with the mountain pine beetle can often be peeled without felling the tree. This of course can be done only when the basal 5 to 10 feet are infested. With trees averaging 12 inches in diameter and with an average height of 5 feet infested, and where no time is lost in travel, a crew can treat about 20 trees per man per day.

The average rate of treating by this method is summarized in Table 6.

The Solar Heat Methods

Consist of: The solar heat or "sun-curing" methods are particularly applicable to the control of barkbeetles, other than flatheaded borers, which attack thin-barked trees. Recently very effective work has been done under the supervision of Mr. J. E. Patterson on the Crater Lake National Park in the control of the mountain pine beetle in lodgepole pine by simply felling the trees and after a few days of exposure turning the logs without peeling them. This method has the advantage of being cheaper than the peeling method, and no attractive influences are set up by the work, as might be the case if the logs were burned. In crowded stands it also avoids the scorching of adjacent trees. The disadvantages are that considerable slash is left in the woods which must later be burned at considerable extra expense if the forest is to be left in good shape, and that it is somewhat more expensive than the burning method.

A modification of the method involving peeling and spreading the bark where it will receive the direct rays of the sun has been applied to the treatment of thick-bark trees, such as western yellow pine, with a fair degree of success. To be successful, however, it is necessary to have summer air temperatures of 85° F. in order that fatal temperatures of 115 to 120° F. may be produced in the bark. Such temperatures do not always prevail during the treating season, especially at high altitudes and on northern exposures, and for this reason the results are erratic. In addition, this modified method is more expensive than the peeling or burning methods, and is therefore of limited applicability.

Sun-Curing Without Peeling

Consists of: This method is particularly well adapted to the treatment of thin-bark trees such as lodgepole pines, on areas where the burning method is objectionable. Trees are felled parallel to one another instead of crisscross and are completely limbed, so as to receive direct sunlight on the trunks. It is also preferable to fell the trees in a north and south direction, in order that a greater arc of the circumference will receive the heat of the sun.

Mr. Patterson found that in the work at Crater Lake Park during 1925 and 1926, at an elevation of from 5000 to 6500 feet, an hour's exposure between 10 a.m. and 3 p.m. on a sunny day was sufficient to produce fatal bark temperatures. Trees were felled and prepared and left exposed to the sun for from two to five days; then the crew returned and rolled them completely over in order to kill the beetles on the other half of the log. A six-man crew could prepare 80 trees per day, and in one day could return and roll all those prepared in a week.

A variation in this method was employed on the Kaibab Project in 1925 in the treatment of yellow pine infested with the Black Hills beetle. The trees were felled, trimmed, the upper two-thirds of the logs peeled and the logs rolled. This avoided the extra expense and trouble of returning to roll the logs.

On this same project some trees were peeled in a strip along each side and were later rolled; but on account of the thick bark at the base of many trees and the shading of other logs by standing trees, these variations of the sun-curing methods were not uniformly effective in killing the broods.

Sun-Curing Without Peeling

This method has been used in the treatment of infestation in western yellow pines of California and southern Oregon. Trees are felled across logs pr other objects in order to hold them off the ground. They are then peeled throughout the infested length and the slabs of bark placed in an opening where they will receive the full rays of the sun during the middle of the day. Bark must be very carefully spread, and must not be in the shadow of other slabs or trees. On north slopes or in canyons it must be carried out to an opening or propped against rocks or trees, in order that the sun's rays may strike it at not less than a 45-degree angle. It can readily be seen that the method is tedious and requires great attention to detail, or it will fail to produce results.

Trap Trees

The fact that many bark-beetles and wood-boring insects are attracted to felled trees suggested to some of the earlier workers the possibility of felling some of the unmerchantable trees of the forest in accessible places to act as traps to absorb the beetles, and later destroying the broods by burning or peeling the bark.

This method has been tried out extensively, both on commercial and experimental projects, but so far without marked success. Although many injurious barkbeetles are attracted to the traps, they do not absorb any large proportion of the destructive beetles present on an area, nor prevent the attacking of healthy trees in the vicinity. Moreover, the cost of preparing and later treating the trap trees is greater than that of treating the infestation in the scattered standing ones. This method, therefore, has not as yet produced results which would justify its general recommendation and adoption.

Spotting

"Spotting" is the work of locating and tagging the infested trees which are to be cut and treated. It is one of the most important phases of the work, as success depends largely upon finding a high percentage of the infested trees. It is important therefore that the forest should be thoroughly and systematically searched by men who know an infested tree when they see one. The work should be started several days before the treating and should be planned so as to keep well ahead of the treating work.

The field methods used in the spotting work are very similar to those described in the marking of sample plots in the detailed survey work, the only difference being a modification of the records that are taken. In general there are two methods used: (1) the topographic method and (2) the strip method.

1. Topographic Spotting

This method is best adapted to country with steep topography and well-defined drainages. It is best handled by one spotter working alone.

The spotter lays out a definite drainage to be covered each day. By following the ridges or around the contours he works back and forth along the slopes, marking all the infested trees as they are found and platting them on his map. A good topographic map on a four-inch-to-the-mile scale or larger is best for this purpose. A good pair of field glasses is also an aid, not only in locating the distant trees but in examining those nearer at hand for pitch tubes and sawdust on the upper portion of the trunks.

With this method it is difficult to cover the area in a very uniform manner, but it has an advantage in being less expensive than the strip method, and can be used in rough country where the latter is not practical.

2. Strip Spotting

The strip method of spotting is primarily adapted to flat or gently-rolling country, or in dense forests where one "cannot see the forest for the trees". Because it is systematic, it is usually more efficient than the topographic method. The extra expense involved can well be justified by the higher percentage of trees found. The advantages of this method are the thorough and uniform spotting of the entire area and the accurate mapping of the infested trees, which in control operations prevents loss of time for the treating crews and avoids "back-tracking".

A three-man crew can best handle the spotting by this method. One man acting as compassman carries the line with compass and pacing, works back and forth through a section, plats the infested trees and maps the topography. The spotters work in a strip on either side of the compassman and mark and tally all the infested trees requiring treatment.

The width of strip will depend upon the density of the timber stand and the intensity of the infestation. In fairly open stands of western yellow pine a five-chain strip can be satisfactorily handled by each spotter. If the timber is dense or the infestation particularly heavy or hard to locate (as in fall work) the width of strip should be cut to four or even two chains. Rarely should the spotting of a strip greater than five chains be attempted by one spotter, as it involves the covering of too large a territory, and the percentage of missed trees is certain to increase.

Size of Spotting Crew

The size of the spotting crew will vary with the amount and intensity of infestation on the area and the spotting method used. Crews of from one man to five have at various times been used.

One spotter can best handle the work by the topographic method, marking and mapping the trees as he goes. Then again for very heavy infestations, where a man can go out and in half a day mark up enough trees to keep the camp busy, spotting is best accomplished by one man. However, when the strip method is to be used and a compass line run, it is very difficult for one man to do this and spot the trees as well. It can be done, but the work is slow and tedious on account of the amount of back-tracking that must be done to get back on the compass line. The tendency is for the spotter to stick too close to the compass line, and thus miss infested trees on the outer edge of the strip.

To overcome this difficulty, a two-man crew using the strip method has at times been used. In this case one man runs the compass and the other man spots in a strip either on one side of the compassman or equally divided by his line; or in some cases the compassman may spot the trees in a narrow strip along his line and let the spotter take the more distant portions of the strip. However, not much more ground can be covered in this manner than by one man working alone, while the expense is doubled.

In order to get full use out of the compassmen, a three-man crew is generally used with a compassman and two spotters, each of whom works a strip on either side of the compassman. While the cost of such a crew is half as much again as for the two-man crew, the area which can be covered is doubled, and for this reason the unit cost of the survey is less. On this account the three-man crew is advocated as the best size of crew for this type of work.

Nothing can be said in favor of a four- or five-man spotting crew. They should be avoided as both expensive and inefficient. The crew attempts to cover too much territory, and as a result the outside men are so far from the compassman that they are unable to keep in touch with him, and are usually unable to tell the direction of the strip or estimate its proper width. As a consequence some territory is covered too intensively and the rest not at all.

On the whole, for practically all infestations of western barkbeetles that are aggressive enough to warrant artificial control methods and where the topography will permit, a three-man crew using the strip method will give the most satisfactory spotting results.

However, for heavy concentrated infestations, the spotting of the trees by a spotting crew can often be dispensed with and the camp or crew foreman entrusted with the duty of marking and treating the trees at the same time. The large centers of infestation can in this way be removed and the area then cruised by a spotting crew to pick up any missed trees in one-tenth or less of the time it would have taken them to mark up all the heavy centers and the large groups.

Selecting the Trees to be Treated

The selection of the proper trees to be treated is a responsibility of the supervising entomologist, and he should carefully instruct the spotters in this respect.

All pines with sickly or slightly fading to sorrel foliage; trees showing signs of woodpecker work or pitch tubes, frass or sawdust in the crevices of the bark or with sawdust or bark flakes on the ground at the base, or with large pitch tubes at the base should be visited and examined for the presence of destructive barkbeetles.

The preliminary examination should be confined to slicing the outer bark to determine if there are entrance or ventilating holes running through to the cambium. This avoids injury to the healthy trees from promiscuous hacking and blazing and is all that is necessary to determine if it has been attacked at the base. If the tree shows signs of insect work it is well to sample it thoroughly enough to determine how successful the attack has been and to what stage the beetles have developed, or whether the tree has been abandoned. Only trees with well-developed broods of beetles should be marked for treatment, and these before the trees have been two-thirds abandoned.

In case of doubt as to whether or not the tree is heavily infested or has been partly abandoned, and a decision cannot be reached after a reasonable amount of inspection, a good rule is to mark the tree for treatment. It is better to err on the side of treating trees that do not need it rather than let some beetles escape by leaving the doubtful trees standing.

Marking the Infested Trees

If the spotter finds that the tree contains a live brood of the destructive barkbeetles, it is conspicuously blazed on at least two sides and tagged with a card or strip of cloth, so that it can easily be found by the treating crews. If the tree is in a large group, the group is so marked that it can easily be located, while each tree in the group is either given a single blaze or tagged with a marker.

Rate of Spotting

The amount of country that can be covered by a spotting crew in one day will be governed largely by the number of infested trees which have to be marked on each section, the character of the topography, and the number of records which must be taken for, and method of marking, each tree.

Chart 1 shows the minimum, average and maximum number of acres and trees that will ordinarily be spotted per day by a three-man spotting crew. Exceptional conditions of topography, weather or character of records which must be taken may reduce these amounts below the minimum shown, but under ordinary conditions the amount of work the spotting crew may be expected to do will fall within these limits.

In yellow pine infestations ranging from 50 to 250 trees per section, a three-man crew can cruise on an average 320 acres per day, and spot from 25 to 125 trees. On areas running less than 40 trees per section, and with gently rolling topography and little brush, as much as 480 to 640 acres may be covered in a day. With infestations heavier than 250 trees per section, the acreage that can be covered will be reduced below 320 acres. With such heavy infestations as occur in mountain pine beetle infestations in lodgepole and Black Hills beetle infestations in yellow pine, a three-man crew can blaze, tally, map and place cards on a maximum of about 500 trees per day. (On the Kaibab Project in 1924 it took a three-man crew nearly two weeks to mark up the trees in one section.)

Working Seasons

The period during which control work can be profitably carried on will depend largely upon the seasonal history of the barkbeetle to be controlled. In general it may be said that the best time to do control work is during the period of beetle inactivity; viz., during the late fall, winter or early spring.

Chart 2 gives the open seasons for the control of western barkbeetles, as determined by their seasonal histories and snow conditions in the various regions. As will be noted, the periods during which efficient work can be done vary with both altitude and latitude. In addition, these periods will vary with local conditions and seasonal changes. The date of starting control in the spring and closing in the fall will be governed largely by local weather conditions, particularly the depth of the snow and the closing up of routes of travel. The date of closing the work in the spring and starting it in the fall will depend upon the condition of the insect broods. The work should stop in the spring at about the time the adult beetles start to form in large numbers and before any emergence has taken place, and the fall work should start at about the time the overwintering broods of beetles have developed the first larval stage.

The usual period for control work is during the fall, winter and spring. Fall work has the advantage of fewer administrative difficulties, easier transportation, less trouble with fires (when the burning method is used), and in addition has proved to yield better results in the control of certain barkbeetles, notably the western pine beetle. Since most of the infested trees are green at this time of year, the chief disadvantages of fall work are the greater difficulty in spotting the trees and in peeling them when such work becomes necessary.

Winter work from an entomological standpoint is entirely satisfactory. A good kill of the beetles can be secured with winter burning even with many feet of snow on the ground; in fact, in Southern California it is the only time that satisfactory work can be done. However, in regions subject to heavy snows, because of transportation difficulties and the loss of time during storms it is more difficult and more expensive than work at other seasons, and as a general thing should not be attempted.

Spring work has been most commonly adopted in control projects. A higher percentage of infested trees can be located then than at any other time. The trees are also much easier to peel, since the broods are in an advanced stage of development. However, these advantages may be offset by the number of beetles that escape from the trees with the first warm weather and the greater difficulty in handling the fires as summer approaches. Transportation is also usually more difficult in the early spring because of the saturated condition of the ground.

Summer work has been used in the fight against the western pine beetle, but without much success. At this time of year the solar heat method is feasible, and the burning method has also been used. Even in the midst of one of the driest summers the burning method was used on the San Joaquin Project without any serious consdquences. However, the precautions necessary to insure safety in summer work make the cost of such work prohibitive. Apparently due to the fact that the beetles are in flight more or less continuously during the summer, the small number which can be found and destroyed in infested trees has little effect in diminishing their aggressiveness. The destruction of a high percentage of predators and parasites during summer work may also be a factor that has militated against success.

The following summary lists the advantages and disadvantages of control work during the different seasons of the year:

FALL CONTROL

Advantages	Disadvantages
1. Destroys beetles in early stages before any emergence has occurred	1. Trees difficult to find
2. Some predators may escape destruction	2. Bark hard to peel
3. Fires progressively easier to control	3. Shorter working season
4. Easy transportation into camps over firm roads	4. Camp may get caught in snowstorm, making it difficult to get out

WINTER CONTROL

1. Destroys beetles before any emergence has occurred	1. Trees difficult to spot
2. Permits covering larger area with seasonal work	2. Bark hard to peel
3. No danger from fires escaping	3. Trees difficult to burn
	4. Transportation difficult
	5. Work interrupted by storms
	6. Usually expensive

SPRING CONTROL

1. Longer working period	1. Many beetles escape through early flight
2. Trees easy to spot	2. Work may be cut short by advent of dry hot weather
3. Trees easy to peel	3. Fires progressively more difficult to control
4. Trees easy to burn	4. Ground soft and early transportation of camps difficult

SUMMER CONTROL

1. Permits treating additional area or doing clean-up work on special projects	1. Has failed to give satisfactory results
	2. Danger from fires great
	3. Solar heat method not always effective
	4. Beetles in flight and only small percentage destroyed
	5. Usually expensive
	6. High percentage of predators destroyed

Cost of Suppression Work

The cost of the various suppression methods will vary with the methods used, the size and spacing of the infested timber, the number of trees in a group; the amount of slash and method of its disposal; the amount of brush on the ground; the character of the topography; the efficiency of the treating crews; the amount of camp overhead; the current rate of pay; the index value of the dollar; and when the burning method is used, the method of handling the fires; weather conditions at the time of burning, particularly humidity and wind conditions and many other factors which at times may be important. Because of the many factors involved it is very difficult to determine in advance the actual cost of any control project. The cost will vary not only between projects but on the same project during different seasons and in different locations. However, the large number of projects carried on in the past cover a wide range of conditions and give a fairly reliable index to the probable cost of such work in the future.

In Table 6 is given the comparative cost of various methods of control, as derived from the actual rate of treating trees by these methods on different projects. A constant figure of $8.00 per day for each treater is assumed in order to make the various costs comparable. This figure represents about the average cost in 1923 of each treater when the overhead of spotting and camp operation were charged against the treating work. The average cost per tree and per M.B.M. as given in the table, therefore, represent the total average cost of treating, including all the items incidental to camp operation, and is the figure generally used in comparing the costs of various control projects. This table shows that peeling lodgepole pines basally without felling is the cheapest control method, while the treatment of large sugar pines is the most expensive.

The probable cost of any contemplated control project may be computed if the method to be used, the intensity of infestation, the average size of the trees and the daily wage of common labor are known. With the given project conditions determine from Table 6 the probable number of trees which can be treated per man per day. Then determine the daily cost of each man. The current wages of treaters (without board) will usually represent from 30 to 35 per cent of the total man-day cost where all the camp overhead is charged against the treating work. The daily cost per man divided by the daily rate of treating will give the probable cost per tree. This multiplied by the estimated number of infested trees on the area will give the probable cost of the project.

The Organization of a Project

A barkbeetle control project may be defined as an enterprise directed toward the suppression of a forest barkbeetle on a specific area and operating under a definite entomological plan. It may vary in size from one man working to control the beetles on his own land to an undertaking contemplating the control of beetles over many square miles and employing hundreds of men.

Aside from entomological considerations, such a project may be a success or a failure, depending upon the character of its administration. Artificial control is expensive at best, and inefficiency in management may very easily result in costs which cannot be offset by the timber saved; while on the other hand a trifling change in methods of management may show a profit. The margin between success and failure is often very narrow.

Barkbeetle control through methods of logging and utilizing the timber can be applied only in very special cases, where the timber is accessible and has a high market value. The methods to be used in such work will vary so greatly with the special conditions that no general discussion can be given which would be at all helpful. The great bulk of the control projects carried on in the past have used the various direct-control methods previously discussed, and the organization of such projects is dealt with in this paper.

The organization of a control project naturally divides itself into two parts, viz., (1) entomological supervision and (2) control administration.

The entomological supervision may be considered as analogous to the architectural supervision of building construction or engineering supervision in railway work. Its function is to make the preliminary surveys, draw up the plans, devise the methods and supervise their application. The work may be handled by trained entomologists of either the federal or state department, or in private work by a man specially trained in insect control work. Outside of making the plans, the entomologist will usually not be called upon to handle the actual control administration. It is best that he act only in an advisory capacity in such matters as camp organization, camp personnel and such other problems as have to do with the administration of the work.

The control administration is comparable to that of the building contractor. Following the plans of the entomologist, the administrator is chiefly concerned with getting the job done as efficiently, quickly and cheaply as possible. This work is usually carried on by the owner of the land, his agent or an organization responsible for the protection of the timber.

On small projects, or projects involving only one owner, the administration is usually handled by one executive, such as the Forest Supervisor on National Forests, the Park Superintendent on National Parks, and the resident manager or forester for operating timber companies.

On large projects where several owners or agencies are involved, a most satisfactory plan is to have the administrative policy handled by a committee or board of directors composed of one representative of each of the cooperating parties. This board makes all decisions for the conduct of the work, such as the fixing of wages, organization of camps, purchase and distribution of supplies and equipment, arranging for communication, cost accounting, methods of slash disposal and similar work incident to the execution of the plan of control. The actual work is then handled through one executive or manager who is responsible to the board for the efficiency of his work. If the project is divided into a number of distinct administrative areas, it may be well to have a manager for each area. Under the area managers will be the camp foremen, each in charge of one camp unit.

The most suitable control organization will have to be worked out for each project, but in any case the responsibility for different phases of the work should be definitely assigned, so as to prevent any conflict in authority or duplication of effort.

CAMP ORGANIZATION

Size of Camps

Adjusting the size of the control camp to fit the conditions found on any project is a matter which requires very careful planning. A camp either too large or too small to fill the particular needs will very adversely affect the efficiency of the work.

Knowing the acreage to be covered, the number of trees to be treated, length of the operating season, rate of treating per man-day and number of necessary camp sites, the size of the camps and the number of men required can be computed.

First: determine the number of laborers required to treat the total estimated number of trees in the specified time. Thus, with 3000 trees to treat in 60 days, it will require 25 men treating 2 trees per day each to do the job.

Second: determine how many spotting crews will be needed to cover the area in the allotted time. This will depend both upon the acreage to be covered and the intensity of the infestation. For instance, under average conditions in yellow pine infestations running from 40 to 160 trees per section, one 3-man spotting crew can efficiently cruise one half section per day. So if 30 square miles are to be covered in a 60-day working period, at a half section per day, it will require only one spotting crew.

Third, adjust the laborers and spotting crews into convenient camp units, so that the treating will just keep pace with the spotting, or lag only slightly behind it. By filling in with the other necessary camp laborers, such as foreman, saw-filer, cook and helpers, the size of the camp to be used is thus determined:

Scattered infestations require small camps which can be easily moved, while large camps can be worked to advantage in the treating of concentrated heavy infestations.

A large camp is more efficient and has less overhead expense per man than a small one. Therefore plan to have the largest camp that is justified by the given situation. However, the point may soon be reached where the cost of frequent moves will offset any saving due to reduction in overhead. Camps of from 20 to 45 men have been found to be efficient working units, since this number of men can be handled by one cook.

Although large camps are desirable, it is not well to put in more men than are required to finish the work within the allotted time. Since the working periods are short anyway, the men do not reach their maximum of efficiency until the latter part of the period. Too many men result in a shortening of the working period, with less production per man and at a higher unit cost.

On a large project, with more or less uniform conditions of infestation and topography, it is particularly desirable to standardize the size of the camps, selecting the size that can best handle the average infestation. In this way coordination is secured among all the interrelated parts, such as the size of tents, cookstove, length of dining tables, size of motor trucks, etc. It also simplifies the supply problem, as the weekly supply for all camps will be practically the same.

Location of Camps

The considerations that determine the location of camps are (1) central location in respect to the working area; (2) general topography of the region; (3) method of transportation; (4) proximity to roads or trails; (5) available water supply, and (6) intensity of the infestation. Camp sites should be selected with the idea of getting the greatest amount of infestation with the least expenditure of time and money. In the first place, the camp must be centrally located with respect to the work, or located so that the men can walk or be transported to within two miles of their work. Ordinarily the maximum walking distance should not be greater than two miles. This will permit working a 12½-square-mile area around the camp, and for light to medium heavy infestations a block of 9 to 16 sections can often be worked without serious inconvenience. If roads and motor transportation are available, this

range may be extended in certain directions. However, the topography and timber boundaries will often limit the area that it is profitable to work from one camp site, and short moves to eliminate the walking are often desirable. If the infestation is heavy, the walking distance should be reduced to a one-mile radius from camp.

In selecting the camp sites all the local factors will have to be weighed to determine what locations are the most desirable. Often the cost of hauling water or of building roads will have to be weighed against the cost of hauling the men to work or against the loss of the men's time where the distance of the work from camp makes long walks necessary.

EQUIPPING OF CAMPS

Having determined the size of camp best adapted to the project in question, this becomes the "standard camp", and the next problem is to decide as to the kind and amount of equipment needed, and to adjust all the various items so as to best meet the individual need. The object here should be to furnish the camp with everything that is essential and with nothing that can be spared, to cut weight down to a minimum and to secure articles that will nest and take up the least possible space. Since camps must be moved frequently, a little thought given to the equipment will save time and expense. Also, if every article of camp equipment is on hand when the camp starts, it will save much grief and lost motion later on. It is hardly advisable to attempt to discuss all the variations that can be made in equipping camps, but a few suggestions may be helpful.

General Camp Equipment

An equipment list is given in Table 8 as an indication of the articles that should be considered in making up these lists for control camps.

Tents

The sizes of tents to be selected will vary from small ones for small camps to large ones for large camps. For large camps it is best to increase the size of the tents rather than their number. The 10x12 tents accommodate four men, and the army pyramidal tents eight men each, without undue crowding. Where transportation is an important factor, tents should be of the lightest duck consistent with durability. With motor transportation weight gives way to serviceability as the first consideration.

For the cook tent, a tent of white 10-oz. duck with high walls is preferable. Its size will depend upon the number of men to be accommodated. For a large camp two tents, one for dining and one for cooking, are desirable. One 16x20 tent can be made to accommodate an 18-man camp as a combined cooking and dining tent, but two are more satisfactory.

Stoves

The cook stove should combine adequate top and oven space with lightness, compactness and durability. The army field range is excellent for the purpose. It "nests" and is comparatively light. It can be used satisfactorily for camps of between 10 and 50 men. Other types of sheetiron stoves are better adapted to smaller camps. For the latter, where transportation is a limiting factor, open fires and Dutch ovens can be used.

For heating the men's tents, nesting sheetiron stoves with flat tops, or Sibley stoves, are very satisfactory. These stoves should be equipped with six lengths of pipe, which can be reversed and telescoped to prevent damage in packing.

Cooking Outfits

Cooking outfits which will "nest" should be selected, and the whole set kept down to the least possible bulk and weight.

For a dining table top, a handy device is made with a strip of 36" canvas, on which at half-inch intervals laths are nailed. This is then covered with oilcloth and makes a very convenient table top of any length desired, which can be rolled up and easily carried when moving camp.

Grindstone

A good grindstone is preferable to emery wheels for sharpening axes, and one should be furnished each camp unless difficulties of transportation make it impracticable.

Record Box

Regardless of the size of the camp, a box should be provided for the safe keeping of the records. With very little trouble one can be provided with shelves or pigeonholes of the proper size to accommodate the various record forms, and the cover so arranged that when open it serves as a writing desk. The Army field desks, if available, are very good for this purpose.

Spotter's Equipment

An equipment list for the spotting crew is given in Table 9.

Compass

The geologist's compass with Jacob's staff is the best equipment for the 3-man spotting crew running strips from a base line; for topographic cruising a hand compass is satisfactory.

Biltmore Rule

Where great accuracy in diameter measurements is not required, a convenient device for the spotter is a Biltmore rule laid off on his ax handle. With a little practice, measurements can be taken to the nearest two inches. The measurements to be used in laying off such a scale are given in Table 1 in the appendix.

Treating Crew Equipment

The equipment for a 3-man treating crew using the burning method is given in Table 8. For a 2-man crew or for use with other treating methods the necessary deductions can be made.

Saws

In addition to one falling saw for each crew, at least two extra saws should be provided for each camp, so that dull saws can be filed without interfering with the work. The best type of saw for this work is the falling-saw pattern, having four teeth to one raker. The length of the saw will depend upon the size of timber to be felled. In insect control work, where a number of tools must be carried, the smallest saw that will do the work satisfactorily should be selected. In timber averaging about 12" d.b.h. a 6' saw is satisfactory, for timber averaging 20" a 6½' saw should be chosen, and for timber averaging 30" d.b.h. a 7' saw or larger will give the best results. Even where the timber runs to small diameters one or two long saws should be provided in each camp in order to handle such large trees as are encountered.

Axes

A double-bitted ax is the best all-around tool for treating work, with a pattern somewhere between that of a falling ax and a swamping ax. The 3½-lb. ax is the best average weight, although a few 3, 3¼ and 4-lb. axes should be available in each camp for the men who prefer them. Some expert peelers curve the handle by steaming it, and are able to remove large sections of bark with a single blow.

Spuds

Barking "spuds" have been used to some extent where the bark does not stick too tightly to the tree. These consist of a short, slightly-curved piece of steel about 3 inches wide and a foot long, sharpened at one end and set into a short, stout handle, or into a long handle for the peeling of standing trees. But since an ax has to be carried anyway, the barking spud is usually of not enough value to bother with as an extra tool.

Wedges

The thin 3½- to 4-lb. falling wedges are the best for the purpose. Each treating crew should carry two of them.

Sledges

The sledgehammer does not often come in for heavy service and so should be as light as possible. The 4-lb. sledges are usually considered heavy enough.

Carborundum Stones

The circular pocket stones are the best.

Files

Eight-inch flat files with one round edge should be purchased for the use of the saw-filer, and when slightly worn can be given to the treating crews for use in touching up their axes if nicked by rocks or pitch knots.

Fire Rakes and Shovels

Fire rakes should be the lighter make of iron asphalt rakes. The long-handle round-point shovels are satisfactory for constructing fire lines where the rakes cannot be used. The McLeod fire tool is a combined rake and wide-bladed hoe, and is excellent for fire-line construction if available.

Camp Personnel

The camp foreman should be not only thoroughly trained in the practical aspects of insect control but particularly well qualified in the art of handling men. He should understand the psychology of labor, know how to apply it, and understand all phases of the work so that he will know whether or not it is being properly done. The administrative efficiency of the work depends largely upon the camp foreman.

The spotters should preferably be active young men with observing eyes and alert minds. They must be ready and willing to do a lot of walking in scouting out the trees and must exercise considerable good judgment in the marking. Familiarity with compass work, pacing and the methods of land survey are an asset. The best training for the spotters is a week or more with the treating crews, where they have an opportunity to observe just what constitutes a"good" bug tree and what type of tree should be passed up. The entomologist should give them considerable training and carefully watch their work to see that the proper trees are being marked and that none is being missed.

The spotting crew should be administratively responsible to the camp foreman for their work--where, when and how much. In addition they should be held accountable to the entomologist for the technical character of their work, i.e., the kind of trees they mark for treatment.

The compassman should be expert at pacing, neat and accurate in mapping, and familiar with the methods of land survey. An accurate map very materially increases the efficiency of the work by reducing the chance of the treating crews missing the trees. A good compassman is an asset, but a poor one is a decided liability.

The cook is a most important man in the camp organization. Here again it is false economy to get a poor though cheap cook. He will soon offset the saving in wages by the food he wastes, by the discontent among the men and the consequent decrease in production. If the camp consists of more than six men, a cook is needed; but one cook with a few helpers can also take care of a hundred-man camp. Therefore the larger the camp the less the overhead for cook and helpers.

Where a camp has more than five crews, a saw-filer is a necessity. For the smaller camps a saw-filer can often be found who will file saws part time and work in the woods when the saws are in shape. Here again a good man is an economy.

The woodsmen employed on insect control work must not only be familiar with the use of an ax and falling-saw, but must be husky and capable of making long walks and doing considerable climbing, as often the most arduous part of the work is getting to the infested trees. Experience has shown that the best type of labor for this work is the local farmer or woodsman. Regular "lumberjacks" have for the most part proved unsatisfactory. They are a highly specialized class of workers and dislike the various jobs connected with peeling and burning the bark, which they consider "out of their line". They also object to the long walks. On account of the walking young men are usually better fitted for the work than older ones, although many very excellent workers among older men have been employed in the camps.

WAGES

The foreman, cook, cook's helpers and spotters are usually paid on a monthly basis, the others on a day basis.

Bonus or contract systems of paying the men, on the basis of the amount of work accomplished, have at times proved very satisfactory. On the Kaibab Project in 1924 the men were paid on the basis of 50 cents per hundred square feet of bark peeled for the first 500 square feet, and then 25 cents per hundred for all additional bark peeled each day. Scalers checked up on the work of each crew and determined the amount of bark surface peeled each day. The work was greatly speeded up by this innovation and through a system of inspection very satisfactory results were obtained. Where the burning method is used the bonus system is not so good, on account of the difficulty of securing proper attention for the fires.

SUBSISTENCE

The subsistence problem will vary considerably with the type and size of camp; character of transportation and the ideas of the cook.

The men require good substantial food, well cooked and in sufficient quantity, and with a reasonable amount of variety. For the sake of economy the use of canned goods would best be cut to the minimum, fancy brands of groceries avoided, and fresh meats and vegetables supplied whenever possible.

The work is usually far enough from camp so that midday lunches can be taken instead of having the men come to camp for dinner. In this connection it has been found that the most economical and satisfactory procedure is for the men to put up their own lunches from cooked foods set out on a serving table by the cooks. In this way each man can get just what he wants, both as to items and quantity.

The supply list used on the Southern Oregon-Northern California Project is given in Table 9 as a suggestion of what is needed. In using this table supplies should not be purchased too far in advance, outside of the staple articles, as the quantity used will vary as the work progresses.

TRANSPORTATION

The transportation problem will vary from the use of pack animals to teams and wagons or motor trucks, depending upon local conditions. The cost of hiring transportation on a contract basis versus the purchase of motor trucks or other alternatives should be carefully weighed to determine what will be the most economical in the long run.

If pack stock is used the number should be cut to the minimum, as there will be very little work for them after the camps have been established.

Teams are less expensive than motor trucks, but their use is limited to the moving of camps and the hauling of supplies. For a small camp they are often very satisfactory.

If motor trucks can be used, they have the advantage of speed in moving camps and supplies, and between times can be used advantageously in transporting the men to the more distant parts of the work. In this way considerably more acreage can be covered from one camp set-up than if the area were limited to what could be reached by walking.

On a large project, with operations extending over more than one season, it will undoubtedly pay to purchase motor trucks if they can be used advantageously. The lighter trucks, with capacities of 1500 to 2000 pounds and speeds up to 35 miles an hour, are very suitable for this work. The use of the trucks should be carefully watched by the area manager to see that they are not used more than necessary. One trip to town per week for supplies is ample, provided the cooks are trained to anticipate their needs a week in advance.

COMMUNICATION

It is very desirable to have telephone communication between camps and the control office. If telephone lines run within three or four miles of the camp this can be arranged by using light emergency telephone wire and the portable field telephones used by the Signal Corps. It is probably not worth while to put in telephones if the existing lines cannot be reached within a three- or four-mile radius.

SOME ADMINISTRATIVE SUGGESTIONS

Do not attempt control unless the area is isolated or can be completely covered during the available field season so as to leave it protected by a mile or more border of beetle-free territory.

Before starting the work make a complete plan, so that every item will be provided for. Make complete lists down to the smallest detail of all camp equipment to furnish one standard camp. Be sure all items are available before assembling the equipment, then upon gathering it check against the lists to be sure that nothing is missed.

Large camps are more efficient than small ones, therefore plan to have the largest camp that is warranted by the given situation rather than several small ones.

Plan the spotting and treating work so that they will progress uninterruptedly from one side of the project area to the other. Do not skip around from one section to another, as this causes much lost motion, extra work for the men in carrying their tools over unprofitable distances, and will result in leaving little patches of work to be cleaned up at considerable extra expense.

Plan the work so that it will progress toward the next camp site. When moving day comes the crews will be at the furthest edge of the old territory and can easily walk in from work to the new camp site. This prevents time being lost in the field, due to the moving, and avoids the expense of transporting the men by trucks.

Start the work on a small scale, and then increase the size and number of camps as rapidly as they can be efficiently handled.

The cost of control can very easily be increased by an excessive amount of overhead. Watch this and keep the non-effective labor operations to a minimum.

Avoid too many bosses. The men should receive instructions and take orders only from the camp foreman. The area manager, the spotters, the entomologist and others should refrain from making any comments directly to the men when they are observing or inspecting the work. All changes should be taken up through the camp foreman; otherwise a good deal of confusion will result and the men will not know whose advice to follow.

RECORDS

The records to be kept will depend upon the requirements of each project and the extent to which the manager wishes to go in making an analysis of the work. In any case the following records will be desired: (1) the number of trees cut; (2) the size of the trees--usually the diameter and number of merchantable logs; (3) the acreage covered and (4) the cost. In some cases it is also desirable to know the location of the trees by legal subdivisions; the names of the owners; diameters and lengths of the infested portions of the trees; species of insects infesting the trees; condition of the broods; length of time spent in treating each tree; production by crews and camps; amount of woodpeckers' work; abundance of predaceous or parasitic insects; a diary of the camp work; and similar notes and records.

In general these records will naturally fall into three groups: (1) the basic treating records, (2) the administrative production records, and (3) the cost accounting records.

The Treating Records

A 3x5" card has been designed for use in control projects, with the necessary data conveniently listed for checking. The cards are numbered serially and tacked to the infested trees by the spotters; at the same time the tree is blazed and numbered accordingly. When the trees are treated the cards are removed by the treating-crew foreman and brought to camp as a record of that crew's work. The cards brought in each day are then checked off on the tree lists in order to make sure that no trees have been missed, and also to serve as a daily record of each crew's production. A sample card is shown in the appendix.

Tags of white sign-painter's cloth have sometimes been used in place of the cards. These have the advantage of being more durable and more resistant to unfavorable weather conditions, and are satisfactory where a limited amount of tree data are to be taken. For more intensive data the card is preferable and has the advantage of being more easily handled in the office checking work.

Spotting and Treating Lists

A tree-list form is carried by the spotters or compassman on which are listed the trees as they are spotted. The serial number, diameter breast high of the tree and number of logs is shown, and in some cases other necessary data. (Sample form is shown in the appendix.) Later, when the trees have been treated and the cards brought to camp, they are checked against the tree list to show which trees have been treated and to determine if any spotted trees have been missed. At the same time the base and top diameter and infested length, which have been taken by the treating-crew foreman, may be entered in the appropriate columns on the tree list. The results will show the total number of trees spotted and treated, the volume spotted and treated, the bark surface treated and other data which can be summarized.

Compassman's Plats

Section plats on an eight-inch-to-the-mile scale are the best forms for mapping the location of the infested trees. (See sample form in the appendix.) Trees should be shown by serial numbers and the groups indicated by a circle containing the number of trees to be found in the group as well as the inclusive numbers of trees in the group. It is also well to show the topography, timber types, roads, trails, springs, fences etc., as a guide to the treating crews in re-locating the trees. Copies of the compassman's maps on which the camp foreman has indicated the area or trees that the crew is to treat are furnished to the treating-crew foreman.

ADMINISTRATIVE PRODUCTION RECORDS

The production records are of temporary value in determining the progress of the work and the efficiency of the various crews. For small camps such records are not of great value, since a good foreman usually knows what each crew is doing, the progress of the spotting in relation to the treating, and can easily see in what ways the production can be increased. For large camps or for projects involving several camps such records are of distinct benefit.

The Crew or Camp Production Record

This is a record in which are summarized each night the total number of trees, volume or bark surface treated by each crew, as indicated by the tree data cards brought to camp. (See sample form in the appendix.) A separate sheet should be used to tabulate the work of each crew, and another sheet can be used to keep the daily camp totals. This crew record is a necessity when the men are paid on a contract basis.

The Weekly Progress Report

Since the period for control operations is usually a short one, it is well to have a progress report submitted weekly by each camp foreman. This should show the number of trees spotted, the number, volume or bark surface treated during the week, and the totals to date. The form shown in the appendix also gives a convenient method of segregating the daily distribution of labor. Such a segregation will often indicate in what way the non-effective labor can be reduced.

Progress Map

The camp foreman should keep up to date a progress map, preferably on an inch-to-the-mile scale, showing the area spotted, the area treated and the number of trees treated on each section or for each forty. This can be kept either on a blank map of the control area or on township blanks, and the spotting and treating indicated by cross hachures or colored pencils. From such a map the progress of the work can be easily followed.

The Cost Records

Ordinarily the camp organization will not be called upon to keep a record of the costs. This is usually done at the central office where the bills are vouchered. In this connection it is desirable to have the cost records segregated by camps and under the following headings:

(1) Salaries and wages (including salary of the area manager, but exclusive of general administrative or entomological supervision;

(2) Subsistence;

(3) Transportation (including current cost of operation plus a depreciation charge on transportation equipment);

(4) Equipment (a depreciation charge should be entered against the cost of the work for equipment of a more or less permanent nature, such as tents, axes, saws etc., usually amounting to 33-1/3 per cent of the original cost);

(5) Miscellaneous.

A more detailed segregation of costs may be made if desired, but ordinarily the above five subdivisions are sufficient.

In connection with the cost records the camp foreman will usually be called upon to keep the following records:

Salaries and Wages

Individual time slips or time books are necessary in order to keep a record of the hours of employment of each man in camp. The segregation of labor records can conveniently be kept in the progress report form.

Subsistence

A record of the number of meals served in the mess house and of the amount of subsistence supplies furnished each camp are usually desired.

Transportation

Each camp foreman is usually required to keep a record of the amount of oil and gasoline used in camp motor vehicles as a basis for ordering additional supplies, or where pack stock and teams are used, the amount of feed required and used.

Equipment

The camp foreman is usually made accountable for all equipment furnished the camp. For this purpose duplicate memorandum property slips are generally used. In some cases the men are required to sign for the axes, saws and other tools assigned to them, and in any case are held responsible for their proper care.

Volume and Bark Surface Tables

For computing the volume of the infested timber in board feet, a volume table made up for the given locality and species of tree should be used, if such a table is available. The U.S. Forest Service can supply such tables for nearly all the western tree species treated in control work and often tables applicable to the specific localities.

The best and most accurate unit for measuring the quantity of infestation on an area, as well as computing the cost of the work, is the area of infested bark surface. Knowing the diameter of the tree and the total height, this can be roughly computed from Table 6, given in the appendix. When the actual infested length, the diameter of the base and top of the infested portion are known, then the bark surface can be computed much more accurately by using Table 7 of the appendix. This table is based on infested length and average diameter of the infested portion.

CHART *1

RATE OF SPOTTING
(Intensive Cruising)
Trees And Acres Ordinarily Spotted Per Day By A 3-Man Spotting Crew (2 Spotters-1 Compassman)

Figures In Parenthesis ( ) = Trees Per Day Per Crew.

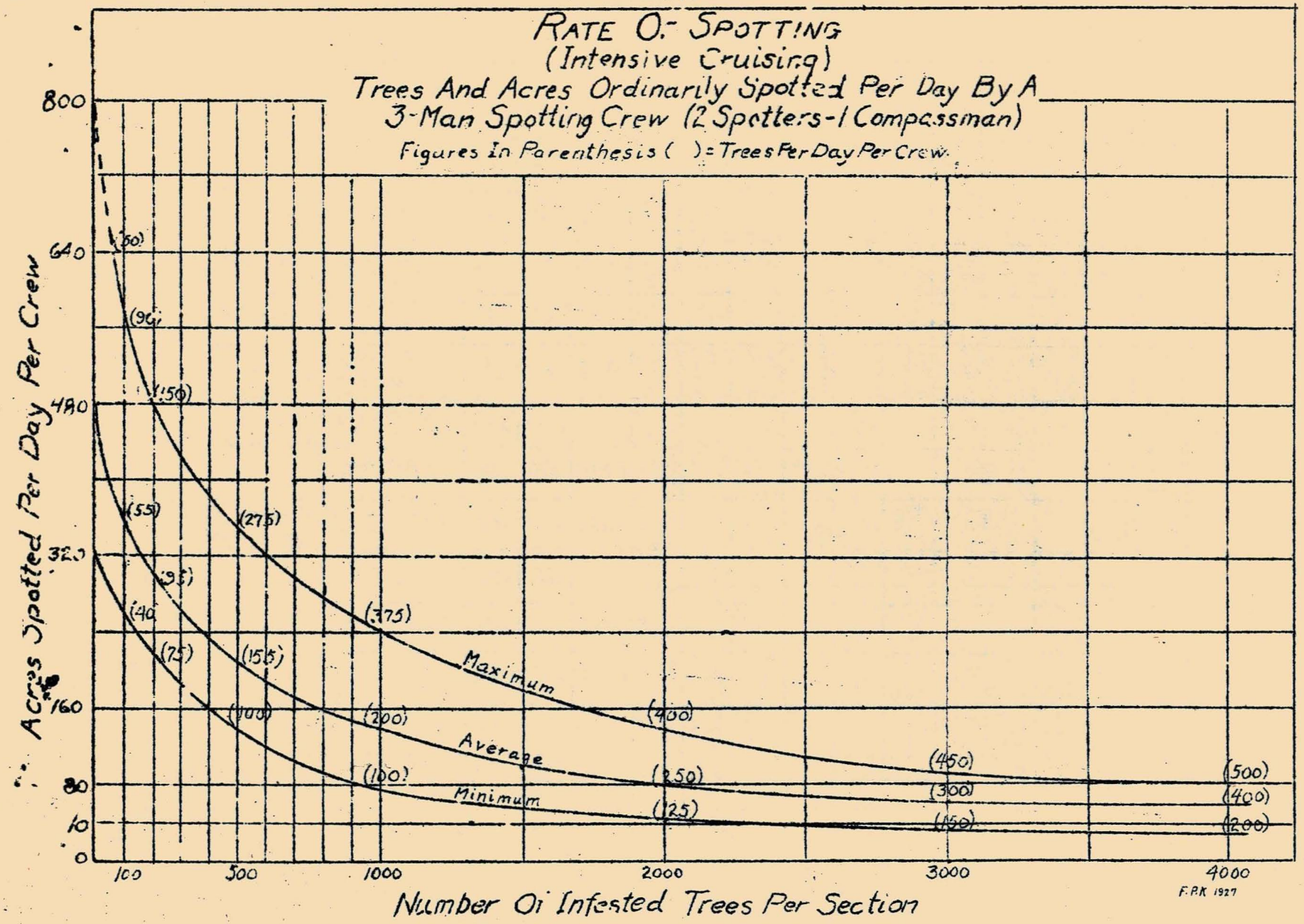


CHART #2

OPEN SEASONS FOR BARKBEETLE CONTROL

Insect	Host	Location				Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
		State	Lat	Long	Elev.												
Western Pine Beetle	Yellow Pine	Idaho	46°	116°	4000'				1		15	Period of Flight		15		15	
		Oregon	44°	121°	5000'			20		25				20		20	
		N. Calif.	42°	121°	5000'	Snow		10		15				1		1	Snow
		Mid. Calif.	38°	119°	5000		20		1						15		15
	Yellow Pine Coulter Pine	S. Calif.	34°	117°	5500'		1		20						25		
Mountain Pine Beetle	Lodgepole Pine	Mid Calif.	38°	119°	8000'					1		10		1	15		
		Oregon	44°	121°	6000'					15	1			10	1		
		Idaho Montana	46°	114°	6000'				25		15	Period		25		20	
	White Pine	Idaho Montana	48°	116°	5000'	Snow			15		10	of		1		1	Snow
	Sugar Pine	Mid Calif.	38°	119°	6000'				1		1	Flight			15		1
	Yellow Pine	Oregon	44°	121°	5000'			20		1					15		1
		Mid. Calif.	38°	119°	5000'		20			15					1		15
Black Hills Beetle	Yellow Pine	N. Arizona	36°	112°	8500'				15		1	Period		15	15		
		Colorado	39°	106°	7000'		Snow		5		25	of		25	1	Snow	
		S. Dakota	44°	104°	6000'				1		20	Flight		1		15	
Jeffrey Pine Beetle	Jeffrey Pine	Mid. Calif.	38°	119°	6000'				15		1			15	15		

TABLES

1 - Measurements for Construction of Biltmore Rule

2 - Total Bark Surface for Each Diameter and Height

3 - Bark Surface by Middle Diameters and Log Lengths

4 - Comparative Costs of Survey Methods

5 - Some Sample Surveys Showing Comparison of Accuracy and Costs of Different Types

6 - Comparative Costs of Control Methods

7 - Actual Cost of Some Typical Control Projects
(a) Western pine beetle in western yellow pine
(b) Black Hills beetle in western yellow pine
(c) Mountain pine beetle in lodgepole pine
(d) Mountain pine beetle in sugar pine

8 - Equipment Lists

9 - Subsistence Supply List

TABLE 1

MEASUREMENTS FOR CONSTRUCTION
OF
BILTMORE RULE

Diameter Breast High	Distance from eye to tree in inches				
	23	24	25	26	27
	Actual distance to be marked on stick in inches				
6 in.	5.29	5.31	5.34	5.36	5.38
8	6.82	6.85	6.90	6.93	6.96
10	8.26	8.31	8.36	8.41	8.46
12	9.67	9.69	9.76	9.83	9.89
14	10.92	11.01	11.09	11.17	11.25
16	12.15	12.26	12.36	12.46	12.56
18	13.34	13.47	13.59	13.70	13.81
20	14.46	14.61	14.75	14.89	15.02
22	15.55	15.72	15.89	16.05	16.19
24	16.60	16.79	16.95	17.11	17.30
26	17.62	17.82	17.99	18.20	18.38
28	18.59	18.82	19.04	19.24	19.44
30	19.55	19.79	20.02	20.24	20.46
32	20.47	20.72	20.97	21.21	21.45
34	21.36	21.64	21.91	22.16	22.42
36	22.23	22.52	22.81	23.08	23.35
38	23.07	23.38	23.69	23.99	24.27
40	23.91	24.24	24.56	24.86	25.16
42	24.71	25.05	25.38	25.71	26.03
44	25.50	25.87	26.23	26.55	26.89
46	26.26	26.65	27.01	27.36	27.72
48	27.01	27.41	27.80	28.17	28.54
50	27.76	28.18	28.57	28.96	29.34
52	28.48	28.91	29.32	29.72	30.11
54	29.18	29.63	30.06	30.48	30.89
56	29.88	30.35	30.79	31.22	31.64
58	30.56	31.04	31.49	31.94	32.38
60	31.23	31.73	32.20	32.67	33.12

From "Notes on the Biltmore Stick", by Donald Bruce,
Proceedings of the Society of American Foresters,
Vol. IX, No. 1, Jan., 1914.

TABLE 2

Total Bark Surface for Each Diameter and Height

Diameter Breast High (inches)	Height of Trees in Feet: Total Bark Surface in Square Feet																			
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
2	5	7	9																	
4	10	14	19	24	29															
6	16	21	28	36	44	51	59													
8	21	28	38	48	58	69	79	90												
10	26	35	47	60	73	86	99	112	125											
12	31	42	57	72	87	103	118	134	150	166										
14	37	49	66	84	102	120	138	156	175	193										
16	42	56	76	96	116	137	158	179	200	221	242									
18	47	63	85	108	131	154	178	201	225	248	272	295								
20		70	95	120	146	171	197	224	250	276	302	328	354	380	406					
22		77	104	132	160	189	217	246	275	304	332	361	389	418	448	477				
24		84	113	144	175	206	237	269	300	331	363	394	425	457	489	519	551	583		
26			123	156	189	223	257	292	325	359	393	426	460	494	529	563	597	632		
28			132	168	204	240	277	314	350	386	424	459	496	533	569	605	643	679		
30				180	219	257	296	336	375	414	454	492	532	571	610	650	689	728		
32				192	233	275	316	359	400	441	484	525	566	608	651	692	735	776	818	
34				204	248	292	336	381	425	470	514	558	602	647	692	737	781	826	870	
36					262	309	355	404	450	497	544	591	638	684	734	780	826	873	921	
38					277	326	375	426	475	525	574	624	673	723	774	823	873	922	972	1021
40						344	395	448	500	552	605	656	709	760	815	866	919	971	1025	1032
42						361	415	471	525	569	635	689	744	798	855	910	965	1020	1073	1129
44						378	434	493	550	607	665	721	779	836	896	953	1011	1069	1127	1182
46							454	515	575	635	695	754	814	874	936	997	1058	1116	1177	1236
48							474	538	600	662	725	787	849	912	976	1039	1114	1178	1239	1301
50								560	625	690	755	820	885	950	1016	1082	1148	1213	1279	1344
52								582	650	718	785	853	920	989	1059	1128	1194	1261	1331	1400
54								605	675	745	816	885	955	1026	1099	1170	1240	1311	1382	1452
56									700	772	846	918	991	1064	1140	1213	1287	1360	1433	1508
58									725	[illegible]	876	951	1028	1103	1181	1259	1334	1410	1487	1560

TABLE 4

COMPARATIVE COST OF SURVEY METHODS

Type of Survey	Acres Covered per Man-Day	Per cent of Area Covrd.	Cost per Acre[1]
Extensive			
Topographic reconnaissance	6,000	0.5	$.00100
Topographic with sample strip	5,600	0.9	.00107
Sample strip with sample section	5,500	1.0	.00109
Sample Strip with sample section	3,800	5.0	.00158
Sample strip with sample section	1,600	10.0	.00375
Intensive			
Sample plot, strip cruise	106	95.0	.0566

[1] Assuming average cost per man-day of $6.00

TABLE 5

SOME SAMPLE SURVEYS SHOWING
COMPARISON OF ACCURACY AND COSTS OF DIFFERENT TYPES

Type	% of Survey	Size of Crew	No. of Men	Acres Covered per Man-Day	Cost per Man-Day	Cost per Acre	Location and Year
			Extensive				
Topographic reconnaissance	-1.0	1-2	7	5,350	$10.15	$.0019	Calif. Survey of 1917
Sample strip and topographic	0.9	2	8	5,600	7.82	.0014	S.Oreg.-N.Calif. Project, 1921
Sample section cruise	3.0	3	3	2,660	5,65	.0021	S.Oreg.-N.Calif. 1925
Sample strip reconnaissance with sample section cruise	4.7	3	3	4,200	6.40	.0015	Kaibab, 1925
idem	5.5	4	12	2,650	6.16	.0023	S.Oreg.-No.Calif. Project,
idem	7.4	2	2	5,280	5.05	.0010	Modoc-Happy Camp, 1923
idem	8.7	3	9	1,620	5.36	.0033	S.Oreg.-N.Calif., 1923
idem	10.0	4	4	2,160	5.55	.0025	Kaibab, 1924
			Intensive				
Strip cruise	88.0	3	3	89	5.69	.064	S.Oreg.-N.Calif. Survey, 1924
idem	85.0	3	3	107	5.50	.052	S.Oreg.-N.Calif. Control, 1923
idem	96.0	3	3	104	4.97	.048	Kaibab(Greenland) 1925

TABLE 6

COMPARATIVE COST OF CONTROL METHODS

Control Method	Average Size of Trees: D.B.H.	Ht.	Volume	Rate of Treating per Treater per Day: Trees	Volume	Average Cost: Per Tree	Per M.B.M.
Lodgepole Pine Projects							
Peeling standing trees at base only							
Small trees (5' infested)	12"	30'	100	20.0	2000	$0.40	$4.00
Medium-sized trees (10' infested)	20"	70'	300	8.0	2400	1.00	3.34
Solar heat by rolling without peeling							
Small trees	12"	30'	100	10.0	1000	.80	8.00
Medium-sized trees	20"	70'	300	6.0	1800	1.33	4.45
Burning without peeling							
Small trees (in groups)	12"	30'	100	10.0	1000	0.80	8.00
Medium-sized trees (in groups)	20"	70'	300	5.0	1500	2.00	5.34
Western Yellow Pine Projects							
Peeling, with felling							
Small trees	12"	30'	100	8.0	800	1.00	10.00
Medium-sized trees	20"	70'	400	5.0	2000	1.60	4.00
Large trees	30"	100'	1500	2.0	3000	4.00	2.67
Burning							
Small trees (without peeling)	12"	30'	100	6.0	600	1.33	13.33
Medium-sized (with peeling)	20"	70'	400	4.0	1600	2.00	5.00
Large trees (with peeling)	30"	100'	1500	2.0	3000	4.00	2.67
Solar heat, with peeling							
Small trees							
Medium-sized trees	24"	90'	1000	1.7	1700	4.70	4.70
Large trees							
Sugar Pine Projects							
Large trees	42"	140'	6800	.4	2720	20.00	2.94

TABLE 7a

ACTUAL COSTS OF SOME TYPICAL CONTROL PROJECTS
WESTERN PINE BEETLE IN WESTERN YELLOW PINE
USING THE BURNING METHOD

Project	Year	Method of Trtmnt.	Average Size of Timber: Dia.	Ht.	Vol.	No. Trees per Sec	Rate of Trt-mt. per M-day: Trees	Vol.	Laborer's Day Wages Only	Average Cost per: Man-Day	Trees	MBM	Acre	Total Spent
Klamath River,	1912	Burning	22.9		590	15	1.6	962	$2.00	$6.00	$2.81	$4.84	$.075	$3,754.13
" N.F., Calif.														
idem	1913	"	26.0		870	7	1.0	856	2.00	5.22	4.03	6.05	.059	1,680.79
Hayfork, Trinity N.F., Calif.	1913	"	20.1		940	22	1.72	1617	2.00	3.88	2.26	2.40	.078	3,517.80
Contour, Sierra N.F., Calif.	1914	"	17.2		560	82	1.9	1060	2.00	4.03	2.12	3.80	.28	4,568.99
Hayfork, Trinity N.F., Calif.	1914	"	17.5		865	10	1.5	1290	2.00	4.13	2.75	3.18	.04	2,872.17
Bullock, Trinity N.F., Calif.	1914	"	24.0		1023	45	1.02	1043	2.00	3.91	3.83	3.75	.28	3,668.09
Chiquito, Sierra N.F., Calif.	1915	"	25.5		1250	20	.85	1060	2.00	5.65	6.65	5.25	.21	2,434.43
Lassen National Forest, Calif.	1916	"	32.2		2077	24	.95	1975	2.00	3.57	3.76	1.61	.137	4,685.82
Chiquito, Sierra N.F., Calif.	1917	"	26.0		1113	25	.93	1090	2.00	4.41	4.74	4.25	.18	2,492.28
Lassen National Forest, Calif.	1917	"	32.0		2980	7	.86	2564	2.00	4.07	4.74	2.10	.072	2,592.80
Antelope, Weed Lbr.Co., Calif.	1921	"	20.0		855	100	1.6	1400	2.50	6.56	4.10	4.79	.64	17,195.55
Antelope, Weed Lbr.Co., Calif.	1922	"	22.0		955	32	2.5	2280	2.80	8.03	3.21	3.55	.16	6,405.81
S.O.-N.C., Klamath Falls, Ore.	1922	"	25.0		1060	51	1.23	1305	2.50	5.95	4.82	4.53	.38	35,246.19
S.O.-N.C., Klamath Falls, Ore.	1923	"	26.0		1198	46	1.38	1639	3.00	5.98	4.36	3.65	.31	57,531.32
S.O.-N.C., Klamath Falls, Ore.	1924	"	24.0		1025	63	1.28	1305	3.20	6.00	4.72	4.60	.465	30,387.17

TABLE 7b

ACTUAL COSTS OF SOME TYPICAL CONTROL PROJECTS
BLACK HILLS BEETLE IN WESTERN YELLOW PINE

Project	Year	Method of Trtmnt.	Average Size of Timber: Dia.	Inf. Lgth:	Vol.	Av. No. Trees per Sec: Trees	Vol	Rate of Trt-mt. per M-Day: Trees	Vol	Average Cost per: Laborers' Wages per Day	Man-Day	Trees	MBM	Acre	Total Spent
Las Animas N.F., Colorado	1908	Peeled	15"									1.07			177.50
Wet Mt., San Isabel N.F., Colorado	1909	Peeled on con-tract	12"	35'		67(?)	7			4.23		.892			550.00
White River N. F., Colorado	1910	Burned bark on trunks	12"	25'	95'		5.2								
Black Hills N. F., S.Dakota	1906	Peeled											6.97		2,546.50
idem	1907	P'l'd & burned	12"	20'	156		2.9	456	2.00		2.37	.81	5.49		2,250.00
Kaibab N.F., Arizona	1922	Peeled	24"	40'	530	214	3.1	1650	2.50		4.86	1.58	2.99	.53	8,965.39
idem	1923	"	22"	45'	550	1100	2.8	1550	2.50		4.38	1.54	2.80	2.64	9,620.25
idem	1924	"	18"	35'	325	601	3.9	1280	2.50		4.52	1.15	3.52	1.08	31,902.08
idem	1925	P'l'd & burned	17"	30'	246	191	3.0	720	2.50		4.97	1.69	6.90	.50	9,073.29

TABLE 7c

ACTUAL COSTS OF SOME TYPICAL CONTROL PROJECTS
MOUNTAIN PINE BEETLE IN LODGEPOLE PINE

Project	Year	Method of Trtmnt.	Average Size of Timber: Dia.	Inf. Lgth:	Vol.	Av. No. Trees per Sec:	Rate of Trt-mt. per M-Day: Trees	Vol.	Average Cost per: Laborers' Wages per Day	Man-Day	Trees	MBM	Acre	Total Spent
N.E. Oregon[1] Whitman N.F.	1910	Burned	9"	35'		2110	5.3		$2.50	$3.24	$.70		2.30	$681.55
idem [1]	1911	P'l'd & Burned	11"	32'	148	269	4.9	900	2.25	3.08	.84	5.65	.25	27,264.52
Ochoco N.F.[1] Oregon	1912	Burned	15"	65'	158	640	4.1	816	2.00	3.36	.82	4.14	.82	2,846.22
idem[1]	1912													
	1913	"	14"	64'	144	2290			2.00		.53	3.66	1.90	6,623.01
Tenaya, Yosemite N.P., Calif.	1913	"	22.4	36'	345	200	4.0	1360	3.00[2]	3.00[3]	.76	2.20	.24	169.00
Cathedral, Yosemite N.P., Calif.	1913	"	22.3	34'	360	267	4.3	1560	3.00[2]	3.19	.74	2.04	.31	979.00
Yosemite N.P., Calif.	1914													
Crater N.P., Oreg.	1925	Brnd.& Rolled	13.7			1375	6.0		3.20	6.98	1.15		2.48	4,954.15
idem[1]	1926	"	14"			745	4.2		3.20	6.12	1.44		1.67	3,603.52

TABLE 7d
MOUNTAIN PINE BEETLE IN SUGAR PINE

Whiskey Creek, Sierra N.F., Cal.	1924			6780	3.6	.3	2275	3.00	5.27	15.72	2.32	.088		846.75

[1] Included treatment of some yellow pine infested with mountain pine beetle
[2] Men boarded themselves
[3] Wages comprised the only cost

TABLE 8

CRUISING EQUIPMENT

For Preliminary Reconnaissance

1 Hand Compass
1 Tally Register
1 Map of area ($\frac{1}{2}$"-to-mile scale or larger, preferably topographic)
1 Notebook with forms
Pencils and erasers
1 Carrier Sack
1 Army Canteen (quart size)
1 Marking hatchet or light ax (2$\frac{1}{2}$ lbs.)
1 pair good binoculars--8-power
1 Diameter tape
Timber crayon

For Estimation Surveys and Control Spotting

For the Compassman

1 Geologist's compass with staff
1 Tally register
1 Map of area ($\frac{1}{2}$" scale or larger)
1 Book section plats
1 Aluminum holder for plats
1 Carrier sack
1 Army canteen (quart size)
Pencils (4H) and erasers

For Each Spotter

1 Marking hatchet or light ax (2$\frac{1}{2}$ lbs.)
1 Aluminum form holder
1 Carrier sack
1 Diameter tape or Biltmore rule
1 Army canteen (quart size)
Pencils and erasers
Timber crayon
Spotting record forms
Tree tags, tacks etc.

TABLE 8, continued

GENERAL CAMP EQUIPMENT[1]
(for 22-man camp)

22 Cots, army, steel folding, 2'6" x 6'6"
1 First-aid kit, U.S.F.S. standard
24 Files, 8" flat, 1 round edge
1 Grindstone or emery wheel
1 Hammer, claw
5 lbs. Haywire
8 Lanterns, standard #2 cold blast
24 Mattresses, 3'x6'6", cotton slab
10 lbs. Nails, assorted
1 Pick mattock
1 Saw, light carpenter's hand
1 Saw-filing set
4 Stoves, Sibley 24", 24 gauge
4 Stovepipe sets, Sibley, 6 lengths, tapered to telescope
4 Dampers, Sibley stove
4 Tents, army squad, 16x16 with poles
1 Tent, cook, 16x20, 10-oz. duck, 4' wall
6 Wash basins
2 " tubs
1 " board

TREATING CREW EQUIPMENT
(2-man crews)

20 Axes, double-bitted, handmade, $3\frac{3}{4}$-lb., swamping pattern
6 Ax handles, D.B.
10 Bottles, pint, for coal oil
8 Canteens, gallon, blanket-covered
8 Carborundum Stones, round pocket
8 Rakes, asphalt, lightest weight
10 Saws, $6\frac{1}{2}$-ft. falling (4 cutters to 1 raker)
10 pairs saw handles
8 Shovels, L.H.R.P.
8 Sledges, 4-lb., flatface
6 Sledge Handles
16 Wedges, flat, thin, 4-lb. falling

[1] Based on equipment used on S.Oreg.-N.Calif. Pine Beetle Control Project during 1922-23-24.

TABLE 8, concluded

SPOTTING AND OFFICE SUPPLIES

1 box for records (10x15x24 outside dimensions)
24 Pencils, 4H
24 Erasers, ruby
1 Cover, leather notebook for time sheets and diary (Form 874C, U.S.F.S.)
24 Timber crayons, black and blue
2 lbs. Tacks
500 Tree Data Cards
500 Envelopes for cards
1 pad section plats, 8" to mile
1 " " forms (compassman)
60 Spotting records
1 pad treated tree record forms
10 Weekly progress report forms
2 maps of area (½" to mile)
10 Township plats (1" to mile)
1 Ownership Map
2 Volume tables
100 Time Sheets
50 Diary sheets
1 Triplicate order book
Pens, ink, blotters, carbon paper

KITCHEN EQUIPMENT

1 Alarm Clock
1 Brush, Scrub
1 Broom
1 Can Opener
1 Chopper, Food
1 Cleaver
1 Corkscrew
2 Dippers, 1-qt.
1 Doughnut Cutter
1 Flour Sifter
1 Kitchen Fork
1 Funnel
2 Gem Tins
1 Grater
2 Knives, Butcher
2 " Paring
1 Ladle, strainer, deep
1 " Skimmer
1 " solid deep
1 Pancake Turner
3 Fry Pans, 14"
1 Fry Pan, 12"
2 Pans, Dish, 17-qt.
3 " Milk
1 " Drip, large
2 " " small
1 " Roasting
2 Pots, 4-qt.
4 Pails, 14-qt.
12 Pie Tins
1 Potato masher
2 Pots, Coffee, 3-gal.
1 Range, Army Field with pipe
1 Rolling Pin
1 Strainer, China Cup
1 Saw, Meat
3 Spoons, Stirring
1 Steel, Butcher's
1 Scoop, Baker's
1 Screen, roll
6 Shakers, salt and pepper
4 Pot Covers
1 Table Top with oilcloth
2 Table Poles 18' long
6 Bowls, 4-qt.
6 " 3-qt.
5 " sugar
25 " soup
25 cups
30 Forks
30 Knives
4 Pitchers, Syrup
4 " Water
30 Plates
4 Pots, Coffee, 4-qt.
30 Saucers
36 Spoons, Tea
36 " Table
3 Platters, deep
1 Wool Sack

TABLE 9

SUBSISTENCE SUPPLY LIST

	Units in Which Usually Supplied	Amount(1) 20 Men-7 Days	Amount(2) 1 Man-30 Days
Meat Products			
Bacon	Side	10 lbs.	2 lbs.
Beef	Quarter	77 "	14 "
Ham	Each	27 "	8 "
Lard	Lb.	10 "	2.5 "
Mutton(3)	Side	2 "	
Pork(3)	Side	3 "	
Salmon	#2 Cans	1.5 cans	.2 "
Dairy Products			
Butter	Lb.	12 lbs.	2.2 lbs.
Cheese	Lb.	5 "	2 "
Eggs	Case (30 doz.)	23 doz.	4 doz.
Milk	Case (48 talls)	54 cans	10 cans
Sweets			
Apple Butter	#10 cans	.5 can	
Honey	5-gal.cans		.5 gal.
Jam and Jelly	#2 cans		1 can
Molasses	#2½ "	.5 "	
Sugar, White	50# sacks	57 lbs.	12 lbs.
Syrup	Gal. cans		.5 gal.
Grain Products			
Cornmeal	10# sack	2 lbs.	.5 lb.
Crackers	3½# box	1.5 "	.3 "
Flour, Graham	10# sack	1.5 "	
" White	49# "	88 "	20
Germea	10# "	2.5 "	.5 "
Macaroni	lb.	2.5 "	.5 "
Middlings	10# "	1 "	
Rice	lb.	3 "	.6 "
Rolled Oats	10# "	3 "	.6 "

1. Amounts used in control camps on S.Oreg.-N.Calif. Project during 1922
2. Amounts computed from various data, including Hopping's control projects in California
3. To be used occasionally to supplement the beef ration

TABLE 9, continued

SUBSISTENCE SUPPLY LIST

	Units in Which Usually Supplied	Amount 20 Men-7 Days	Amount 1 Man 30 Ds.
Vegetables			
Fresh (1)			
Beets	Lb.	1 lb.	
Cabbage	"	8 "	
Carrots	"	5 "	
Onions	"	8.5 "	2 lbs.
Parsnips	"	4.5 "	
Potatoes	"	74 "	15 "
Rhubarb	"	3 "	
Spinach	"	2 "	
Dried			
Beans, Bayou	"	3.5 "	2 "
" Wh.Navy	"	4 "	1 "
Canned			
Beans, Pork and	Case (24 #2 cans)	2 cans	.5 can
Corn	" (")	4 "	.3 "
Hominy	Can (2½#)	1.5 "	
Peas	Case (24 #2 cans)	4 "	1 "
Pumpkin	Can (10#)	1 "	
Tomatoes	" (2½#)	8 "	3 "
Fruit			
Fresh			
(Rarely available)			
Dried			
Apples	26-lb. box	4.5 lbs.	1 lb.
Peaches	25-lb. "	6 "	1 "
Prunes	25-lb. "	6 "	1 "
Raisins	25-lb. "	6 "	1 "
Canned (2)			
Apricots	2½ " can		1 can
Peaches	2½ " "		1 "
Pears	2½ " "		1 "
Staples			
Baking Powder	5 " "	1.7 "	.5 lb.
Cornstarch	Lb. pkgs.	1 "	.2 "
Salt	" sacks	5 "	1 "
Soda	" pkgs.	.2 "	
Yeast, Magic	Box of 18	2.5 pkgs.	.5 pkg.

1. Supply fresh vegetables whenever possible, as they improve the menu and reduce the cost, being cheaper than canned vegetables
2. Canned fruits are expensive and should be replaced by dried fruits to as great an extent as possible

TABLE 9, concluded

SUBSISTENCE SUPPLY LIST

	Units in Which Usually Supplied	Amount 20 Men-7 Days	Amount 1 Man-30 Ds.
Beverages			
Chocolate	5-lb. cans	2 lbs.	.5 lb.
Coffee	5-lb. "	6 "	2 "
Tea	1-lb. pkgs.	.7 "	.25 "
Condiments			
Catsup	Pt.bottles	1 gal.	2 pts.
Pickles	1-gal.keg	2 qts.	1 "
Vinegar	1-qt. bot.	1 "	.5 "
Spices			
Allspice	2-oz. cans		
Cinnamon	4-oz. "	1 oz.	
Cloves	4-oz. "	1 "	
Extract, Lemon	8-oz. bot.	1.5 "	.3 oz.
" Vanilla	8-oz. "	1.75 "	.5 "
Ginger	4-oz. can	2 "	
Mapleine	4-oz. bot.	.5 "	
Nutmeg	4-oz. can	3 "	
Mustard	4-oz. "	2 "	
Pepper, Black	1-lb. "	3 "	1 "
" Red	2-oz. "	1.5 "	.3 "
Sage	2-oz. "	1 "	
Miscellaneous Foodstuffs			
Coconut	Lb. pkgs.	.5 lb.	
Tapioca	Lbs.	1 "	.2 lb.
Wesson Oil	Pt. cans	1 pt.	
Sundry Supplied			
Candles, 14-oz.	Doz.		4
Lime, Chloride	1-lb. can	.5 can	
Matches	5-pkg.cartons	5 boxes	1 box
Oil, Coal	5-gal. cans	1.7 gal.	.5 gal.
Napkins, Paper	100's	100	25
Sacks, "	1000's	100	25
Soap, Laundry	Bar	5 bars	1 bar
" Hand	"	3 "	1 "
" Powder	2½-lb. pkg.	1 pkg.	

SAMPLE REPORT OUTLINES

Outlines that suggest the points to be covered in any report are always helpful. For this reason a number of sample outlines are appended which cover the various reports usually submitted in connection with barkbeetle infestations from the time the infestation is first reported, examination of the infested area through the control project itself to the final determination of the results of the control work.

Strict adherence to these outlines is not at all mandatory, since each situation will involve special considerations which must be dealt with as the occasion demands. In most reports many of the sub-topics may be omitted. However, all reports should in general cover the main topics listed in these outlines.

1. Reports of Preliminary Reconnaissance of Infested Forest Areas

This report is intended for the use of Forest Rangers, timber owners and others who have occasion to report the first signs of a barkbeetle epidemic. Only essential data are included.

2. Annual Forest Insect Report

This form is used in District 5 of the U.S. Forest Service by rangers in making annual report of insect conditions on their districts.

3. Reports on Barkbeetle Estimation Surveys and Examination of Infested Areas

This report is made by the forest entomologist or control expert after a careful survey of the infested area, and suggests the points that should be covered by his report and recommendations.

4. Subsequent Reports on Examination of Infested Areas

This outline is also for the use of the control expert or entomologist in reporting subsequent examinations of infested tracts, and is similar to Outline 3 except that the basic data as to the area do not need to be repeated.

5. Working Plan for Barkbeetle Control Projects

Just before the opening of control work on any project each season, the supervising administrative officer should prepare a detailed working plan of what is to be done and how. This outline suggests the points to be covered.

6. Reports on Completion of Seasonal Work on Control Projects

After the completion of control work each season, the administrative officer in charge of the work will usually be called upon to make a report of what was done. This outline gives a standardized method of reporting such work.

7. Reports on Results of Control Work

This outline suggests the points to be covered by the control expert or entomologist in reporting his examination of a treated area and the results which have been secured from control work.

OUTLINE 1
for
Reports of Preliminary Reconnaissance of Infested Forest Areas

1. Location of the Area

   (a) State, county, national forest, national park or ranger district
   (b) Local name of area

   (c) Location by legal subdivisions

2. Timber Affected

   (a) Timber type

   (b) Species of trees involved

   (c) Affected reproduction, second growth or mature stands; size of trees--diameter, height or mature stands
   (d) Number acres affected and ownership

   (e) Number of trees killed on area

   (f) Average number killed per average timbered section

   (g) Value of stand per M.B.M.

3. Insects Responsible for Damage

   (a) Barkbeetles, flatheaded borers, defoliators or unknown (Have the insects been sent to a specialist for determination?)
   (b) Trees dying singly or in groups

   (c) Losses appear to be decreasing, increasing or stationary

4. Recommendations

   (a) A more detailed survey

   (b) Control operations

   (c) Disposal of timber through administrative use or sale

OUTLINE 2
for
ANNUAL FOREST INSECT REPORT

Forest _____

Ranger District _____ Date of Field Examination _____

1. Indicate the tree species dying from insect attack during the past season and approximate number dying per(average)timbered section

Yellow Pine	_____	White Fir	_____
Sugar Pine	_____	Douglas Fir	_____
Jeffrey "	_____	Incense Cedar	____
Lodgepole"	_____	Other Species	____

2. What insects appear to be responsible for the damage? (Barkbeetles, flatheaded borers, defoliators, unknown)

3. Does the damage occur in reproduction, second growth or mature stands?

4. Do the dying trees occur singly or in groups?

5. In your opinion are the losses decreasing, increasing or balanced?

6. Are there any special areas where insect losses are now serious or threaten to become so? If so, answer the following questions, using additional forms if more than one special area is reported:

Name of area affected _____ No.Acres _____
Location by legal subdivisions _____
Timber type _____ Range in Elevation _____
Value of stand per M.B.M. _____
For each tree species involved,what is your estimate of the total number of trees killed by insects on entire area during past year

Tree species	Yellow Pine	Sugar Pine	_____
Total number of trees on area	_____	_____	_____
Average per section	_____	_____	_____
Average board foot volume per tree	_____	_____	_____

Proportion of ownership by acreage: Government _____
State _____
Private _____

In your opinion what action should be taken?
Special examination _____
Control project _____
Administrative use _____

Will it be possible to dispose of infested trees through free use, administrative use or sale,so as to insure killing of the broods?

Remarks and Recommendations
(Cover any points not included above that you consider important)

Approved _____ Submitted _____
Forest Supervisor _____ Title _____

OUTLINE 3

for

Reports on Barkbeetle Estimation Surveys and Examinations of Infested Areas

1. Introduction
   (a) Object and scope
       Give reasons for making the survey, and the objectives
   (b) History
       Brief summary of previous history of the area and epidemic, reports by forest officers and steps leading to present examination
   (c) Survey methods
       Character of the survey conducted, probable accuracy, personnel concerned and cost, man-day time, miles of strip run, acres intensively cruised, per cent of cruise, etc.
2. SURVEY DATA
   (a) Area
       Description of the area, location, topography, soil conditions, slope, exposure, elevation and timber type and local conditions
       Timbered acreage and ownership involved
       Timber resources involved, volume and value
   (b) Insects
       What insects are causing the damage and their relative importance
       Past insect losses; evidence of old epidemics
       Present insect losses; number of trees and volume freshly infested
       Character of present epidemic--spreading, increasing, balanced or decreasing
   (c) The situation by units, districts or small subdivisions
       Number of trees, volume and acreage affected and value of loss by units or by sections
3. CONCLUSIONS
   (a) What progress can be expected in the infestation?
       Estimated loss if no control work is done
4. RECOMMENDATIONS
   (a) Statement of what should be done; a protection plan
       Further examinations
       Administrative use
       Control project
   (b) If control proposed:
       Method of treatment
       Time of work
       Working periods proposed
       Area to be included; division into entomological units
       Treatment required
       Probable cost
       Probable results to be secured
       Proposed name of project

Appendix

1. Table of acreage by units and ownership.
2. Table of trees, volume and value killed during past year(by units)
3. Control treatment required
   Including trees, volume, acres, man-days and cost
4. Map of area
   Showing location, distribution and intensity of infestation, and the division of the area into units

OUTLINE 4
for
Subsequent Reports on Examinations of Infested Areas

1. INTRODUCTION
   (a) Object
       Reason for making subsequent examination and objectives
   (b) History
       Brief history of what previous examinations have shown
   (c) Survey methods
       Character of the survey conducted, methods used, accuracy, personnel, cost, time, area covered intensively and extensively, per cent of cruise, etc.

2. SURVEY DATA
   (a) Insects
       Brief review of past losses
       Any changes that have occurred in status of infestation since last report
       Present character of insect losses
   (b) The situation by units or other districts
       Number of trees, volume and acreage affected and value of loss for current year by units or sections
   (c) Results secured from control
       Statement of what has been accomplished in the carrying out of previous recommendations, giving available data

3. RECOMMENDATIONS
   Statement of what should be done at the present time
   New areas tobe worked
   Cost of additional control
   Future studies to be conducted

APPENDIX
   1. Table of trees, volume and value killed during past year, by units
   2. Table of control treatment now required, including trees, volume, acreage, man-days and cost
   3. Map of area
      Showing location, distribution and intensity of present infestation

OUTLINE 5
for
Working Plan for Barkbeetle Control Projects

1. Name of project, area and unit

2. Brief review of past work, if any, and accomplishments

3. Amount of work to be done during the present season
   (a) Period of the work
       Give approximate dates of opening and closing
   (b) Number of trees to be treated
   (c) Volume to be treated
   (d) Acreage to be covered
       Designate areas by name and by legal subdivisions
       Accessibility of the areas
   (e) Probable number of men required to complete the work within the allotted time
   (f) Probable cost
       Per tree, M.B.M. or acre
       Total cost

4. The spotting work
   (a) When to start
   (b) Method to be used
   (c) Kinds of trees to be marked
   (d) Size and organization of spotting crews
   (e) Records to be kept
   (f) Equipment needed

5. The treating work
   (a) Methods to be used
       State if different methods are to be used for small and large trees or for other species of barkbeetles
   (b) Size and organization of treating crews
   (c) Records to be taken by treating crews
   (d) Treating-crew equipment needed

6. General plan of organization
   Cooperation

7. Organization of camps
   (a) Size and number of camps required
   (b) Best location of camps
       In relation to water, roads and the work
   (c) Camp personnel
       Name officer to be in charge
       Number of spotters, saw-filers, cooks, helpers, woodsmen etc.
       Proposed wages
   (d) Method of transportation
       Pack animals or trucks needed
   (e) Subsistence supplies
       Method of handling
   (f) General camp equipment needed
   (g) Reports to be required

OUTLINE 6, concluded

(b) Labor and cost distribution

Supervision

Salaries and expenses of superintendents, camp foremen, etc., and other overhead items

Control operations

Spotting (salaries of spotting crew)

Treating (wages of treating labor only)

Subsistence

Supplies and cooks' and helpers' wages

Number of meals served and cost per meal

Transportation

Wages of teamsters, truck drivers, hire of teams and costs of transportation supplies

Equipment

Including only a depreciation charge of 33-1/3% of original cost or rental, also cost of repairs, saw-filer's wages, etc.

Non-effective items

Including cost of miscellaneous items and wages of men employed in non-effective operations, such as camp sanitation, fire suppression, etc.

Percent of non-effective cost to total cost

(Tabulate under the above items the total number of man-days, total cost and total cost per man-day. A more detailed cost accounting may be used if desired.)

6. Average costs, tabulated

Cost per tree treated
" thousand board feet treated
" acre treated
" acre protected
" man-day of treating labor
" man-day of total labor

7. Conclusions and recommendations

General discussion of future plans and improvements in methods

Appendix

A map should accompany the report, showing area protected and area treated.

OUTLINE 7
for
Reports on Results of Control Work

1. Introduction
   (a) Brief history of previous work, giving location of work and period of operation
   (b) The survey method or manner of obtaining data on results

2. The data obtained
   (a) Acreage covered by work and area left untreated
   (b) Trees treated and number missed
   (c) Volume treated and amount left untreated
   (d) Bark surface treated and amount untreated
   (e) Progress of infestation on adjacent areas undisturbed by control
       By trees, volume, bark surface or percentage of stand
   (f) Progress of infestation on control area
       New infestation by trees, volume, bark surface or percentage of stand
   (g) Character of old and new infestation as determined by comparative brood counts
       Any change observed in amount of predator, parasite or woodpecker work

3. Conclusions
   (a) General results obtained
   (b) Net effect of control operations after deducting the influence of natural factors
       The percentage of reduction
   (c) Amount of timber saved in terms of trees or volume
   (d) Value of timber saved and net profit (or loss) from the control operations after deducting the cost of control work

4. Recommendations for future work

SAMPLE FORMS
for
INSECT CONTROL PROJECTS

1. Tree Data Card
2. Treating Record
3. Treating Plat
4. Production Record
5. Weekly Progress Report
6. Progress Map
7. Section Plat

   Sample Section Plat with Map Legend
8. Spotting Record

TREE DATA CARD

(Front side)

Insect Control
Form 1d

Perforated Tab For Binding

Project Area ..... Unit ..... Tree No. ....

Killed by .....
Year ..... Summer brood .....
Winter brood ..

Location .....
Forty ... Sec. . T. ... R. ...
Owner .....

	D.B.	D.M.	Ips	
Attack				
Parent adults				
Eggs				
Larvae 0-.5				
Larvae .5-1				
Pupae				
New adults				
Emerging				
Abandoned				
Infested lngth				

FOLIAGE
Green
Fading
Sorrel
Red
Black

Yellow Pine
Sugar Pine
.....
D.B.H.
Logs (16')
B.F.

Remarks:

Date ..... Camp No. ....
Spotter .....

(Back)

CONTROL DATA

Date of felling ..... Date of treating .....
Infested length ..... Dia. at base .... Dia. at top .....

Method of Treatment:-

Tree	Brush	Log	Bark	Insects
Left stand	Left on	Laid flat	Left on	Burned
Felled	Trimmed	Off ground	Peeled ½	Suncured
	Piled	Rolled	" ½	
	Spread		" all	

Size of Crew: _____ Treating time _____ man mins.
Remarks:-

Crew Foreman _____

Perforated Tab For Binding

(Size of card 3" x 5")

Insect Control
Form 2e

TREATING RECORD

Project Area ..... Unit ..... Camp. .....

Tree Species ..... Insect ..... T. ... R. ... Sec. .....

SPOTTED						TREATED						
Spotted by ..... Date						Treated by ..... Date						
Tree No.	DBH	Logs	Volume		Remarks	Diameters Base	Diameters Top	Inf Lngth	Bark Surface			Remarks

Insect Control
Form 3b

TREATING PLAT

Project Area ..... Unit ..... Camp No. ....

Date ..... Compassman ..... T. .... R. ..... Sec. .....

Remarks: _____

_____

Insect Control
Form 4a

PRODUCTION RECORD

Project Area ..... Unit ..... Camp .....

Month ..... 19 ..... Checked by ..... Crew .....

Day	Trees	Volume	Bark Surface		Men in Crew	Man Days	Rate Per Man Day					Remarks
							Tree	Vol.	SqFt			
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												
31												
TOTAL												

Form 5c

WEEKLY PROGRESS REPORT

Project Area ..... Unit ..... Camp .....

Report For Week Ending ..... Signed .....

SPOTTED				TREATED					
Crew Section Day	Trees	Acres		Crew Section Day	Trees	Volume	Acres		Remarks
Brt. Fwd.				Brt. Fwd.					
Total This Week				Total This Week					
Total To Date				Total To Date					

LABOR DISTRIBUTION--MAN DAYS.

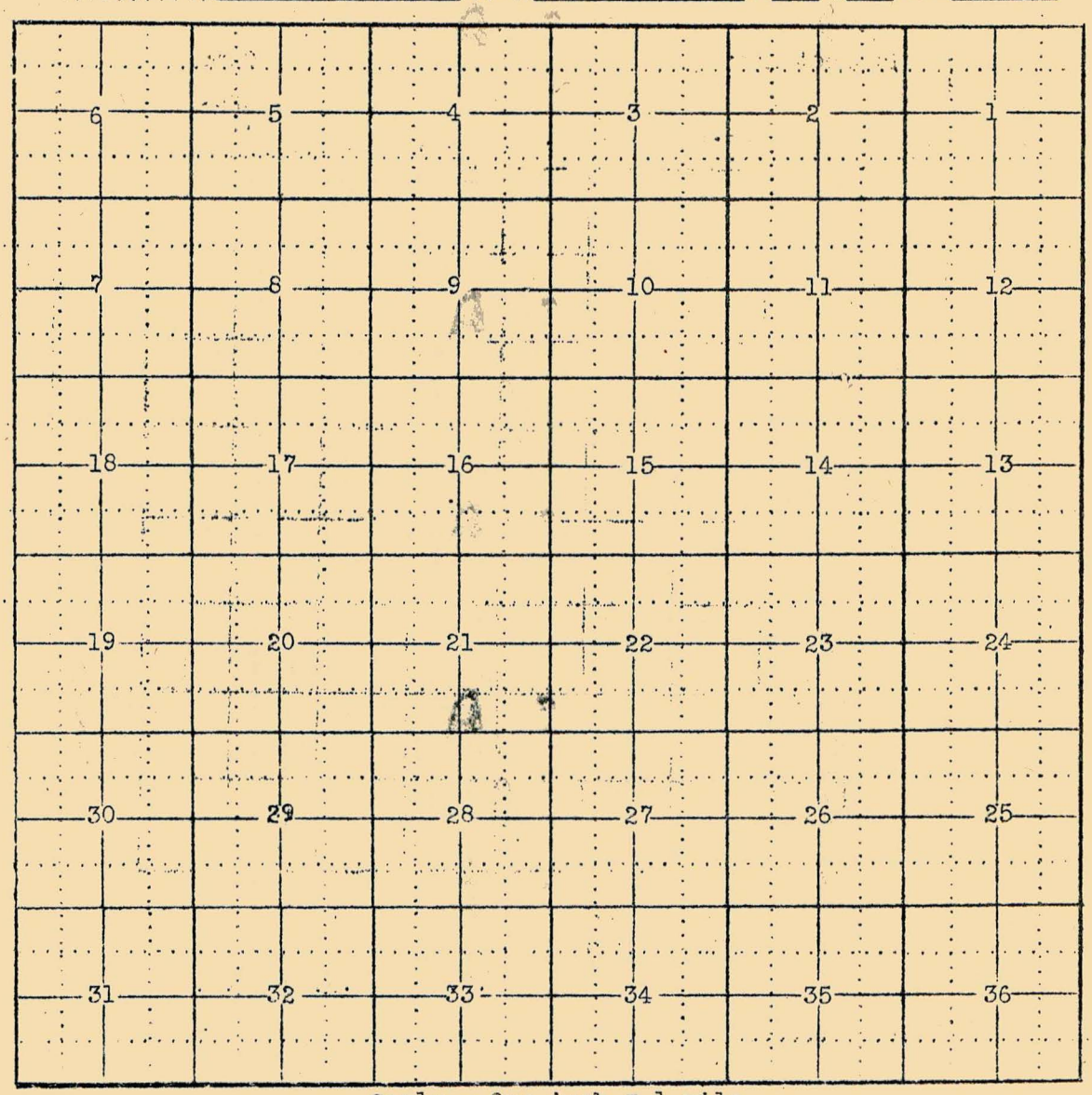
	Supervision	Control Operations			Subsistence		Transportation		Equipment		Non-effective			Total	Total
Day	Foremen	Spotting	Treating	Other	Cook & Helpers	Other	Moving Camp	Other	Saw Filing	Other	Camp Sanitation	Fire Suppression	Other	Man Days	Meals
Brt. Fwd.															
Sun.															
Mon.															
Tues.															
Wed.															
Thurs.															
Fri															
Sat.															
Total This Week															
Total To Date															

Insect Control
Form 6a

PROGRESS MAP

Project Area _____ Unit _____ Camp No. _____

Mapped by _____ Date _____ T. ___ R. ___ Mer. _____



Scale.- One inch = 1 mile.

Remarks: _____

(Size of sheet 8" x 10½")

(Perforated Tab)

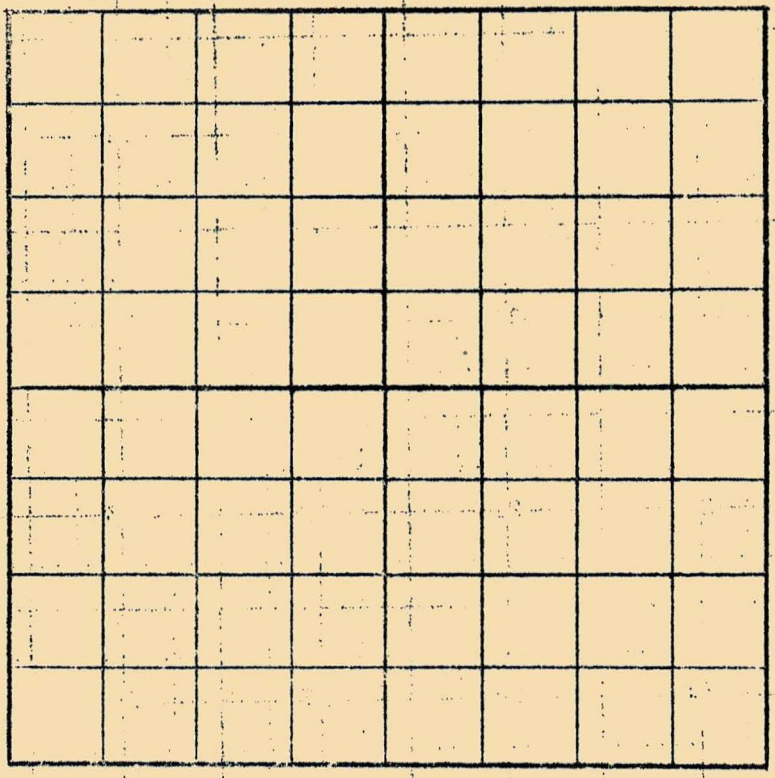
Insect Control
Form 7c

SECTION PLAT

Project Area ..... Unit ..... Camp No.

Date ..... T. ..... R. ..... Sec. ....

Compassman ..... ¼ Sec.



Timbered acreage .....

Volume B.F. per acre .....

Percent of Y.P. ..... S.P. ..... L.P. .....

Character of timber stand .....

Topography .....

General slope and exposure .....

Cruising time ..... Days ..... Hours .....

Remarks: .....

.....

.....

.....

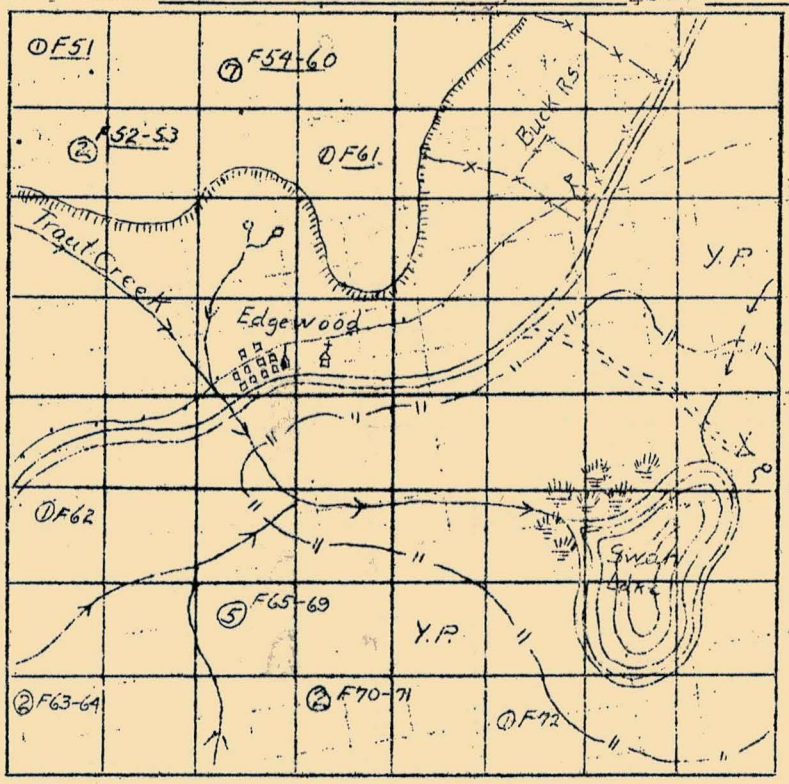
(Size of sheet 5" x 8")

SAMPLE
SECTION PLAT

Project Area 3 Unit B1y Camp No. 16

Date 5/16/27 T. 37N R. 15E Sec. 7

Compassman T. L. Jones ¼ Sec.



MAP LEGEND

Infested Trees ③ F61-63
Number within circle indicates number of trees in group.
Numbers outside of circle are the inclusive serial numbers.
The letter represents year of attack, or spotters symbol.
Numbers are underscored when trees are treated.

Roads (primary)
Roads (secondary)
Trails
Buildings
Schools
Churchs
Good camp sites
Telephone lines
Streams (live)
Streams (dry)
Lakes
Springs
Marsh
Cliffs
Type boundary
Fences

(Perforated Tab)

Insect Control
Form 8c

SPOTTING RECORD

Project Area ..... Unit ..... Camp No. ....

Date ..... Spotter ..... T. .... R. .... Sec.

Tree No.	Killed By	DBH	Log	Volume				Remarks
Totals								

(Size of sheet 5" x 8")

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